NTEL B560 BOARDS BUDGET IS KING AGAIN

apc

SINCE 1980

YOUR EXPERT GUIDE TO TODAY'S TECH

JULY 2021 #495

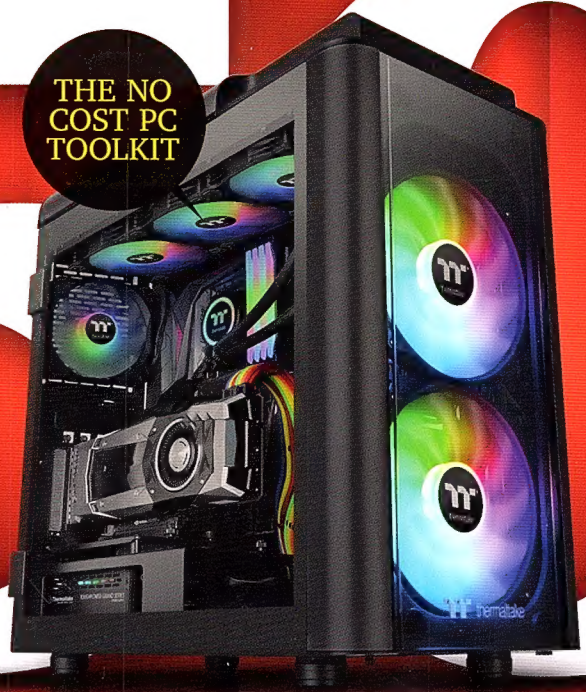
FEATURE

PCs IN SPACE

HOW NASA SENT THE PC TO THE FINAL FRONTIER

50

THE NO COST PC TOOLKIT



WINNER!

INTEL CORE i5 11400F

REDEFINING THE BUDGET CPU MARKET

TECH HISTORY

THE COMPUTER THAT HELPED WIN WWII

Essential FREE PC programs

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INSIDE!

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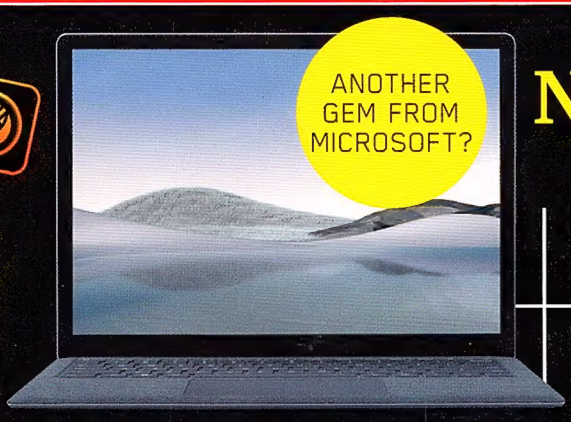
Image editing options from beyond Adobe



ANOTHER GEM FROM MICROSOFT?

IN THE LAB

New Surface Laptop 4

Intel & AMD models head to head

KINGSTON NV1 BUDGET PCIE SSD

NBN SMB Solution for Ethernet WAN (FTTP, HFC, Fixed Wireless, Satellite)

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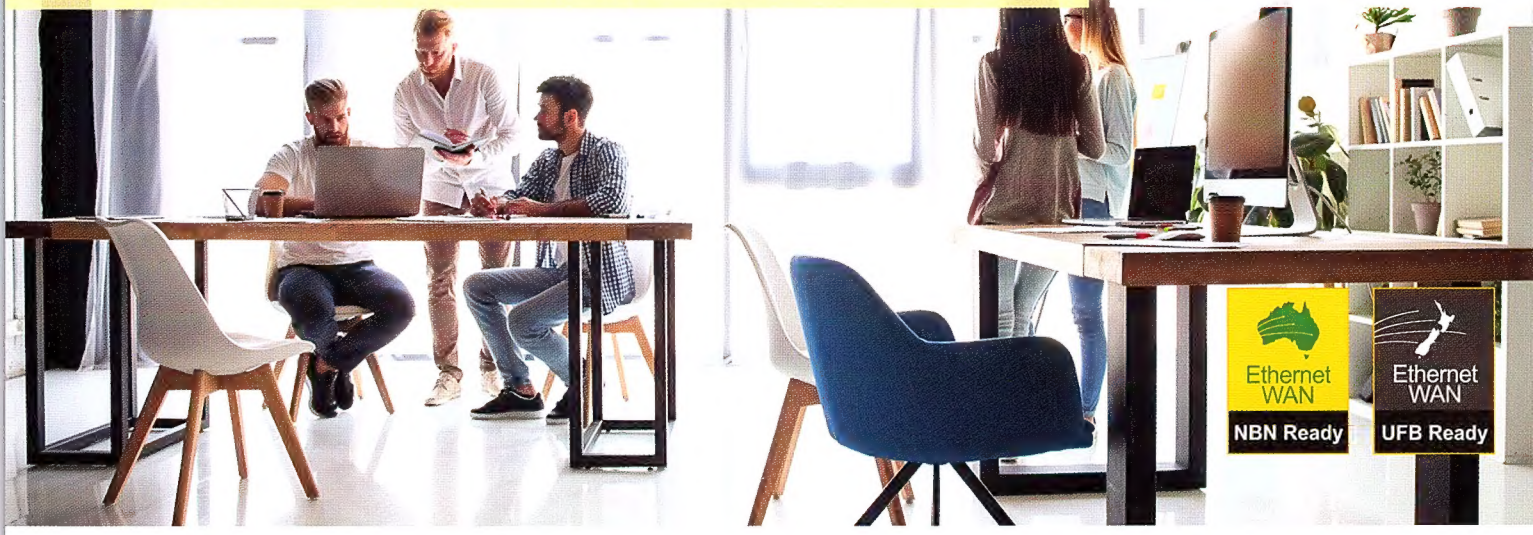

Vigor2927 Series

Dual-WAN broadband routers with 1 x configurable GbE WAN/LAN port, 5 x GbE LAN ports, SPI Firewall, 802.11ac Wi-Fi, and 50 x VPN tunnels including 25 x SSL-VPN tunnels

apc HOT PRODUCT

50x VPN

Vigor2927ac

- 1 x Gigabit Ethernet WAN port and 1 x configurable GbE WAN/LAN port for Failover, Load-Balancing and High Availability mode
- Two USB 2.0 ports for connection to two 3G/4G LTE USB modems, FTP server, network printer and thermometer
- 5 x Gigabit LAN ports with multiple subnets and 60,000 NAT sessions
- 50 x VPN tunnels (including 25 x OpenVPN/ SSL-VPN tunnels) with comprehensive secure protocols
- Fast VPN throughput, VPN load-balancing and backup for site-to-site applications
- 16 x VLANs for secure and efficient workgroup management
- IPv6 & IPv4; Up to 1022 IP addresses and 8 IP subnets
- Integrated IEEE 802.11ac (AC1300) wireless Access Point; dual band; up to 867 Mbps throughput (ac/Vac model)
- 2 x FXS VoIP ports (Vac model)
- High Availability mode
- Object-based SPI Firewall and CSM (Content Security Management) for network security
- Supports VigorACS 2 and VigorACS 3 Central Management Systems for remote management
- SD WAN capability when used with VigorACS 3
- Central VPN Management for 8 remote Vigor routers
- Central AP Management for deployment of 20 VigorAP's
- Central Switch Management for 10 VigorSwitches
- 2 years back to base warranty

Vigor2135 Series

Broadband routers with 4 x GbE LAN ports, SPI Firewall, 802.11ac Wi-Fi and 2 x VPN tunnels including SSL-VPN tunnels

2x VPN

Vigor2135ac

- NBN (National Broadband Network – Australia) Ready to connect to NTD (Network Termination Device)
- 1 x Gigabit WAN port with 2 x USB ports for 3.5G / 4G Mobile Failover
- 4 x Gigabit LAN ports with 50,000 NAT sessions and IPv6
- NAT throughput over 600Mbps
- IPsec VPN throughput at 150 Mbps (AES 256 bits)
- Object-based SPI Firewall, Content Security Management (CSM) and QoS
- IPv6 & IPv4
- 802.11ac (AC1300) Wi-Fi up to 400 + 867Mbps speed (ac/Vac model)
- 2 x FXS VoIP (Vac model)
- 2 x VPN tunnels including OpenVPN/ SSL-VPN tunnels
- 2 x USB ports for 3G/4G Backup, FTP server, network printer or thermometer
- Supports Central AP Management for deployment of 2 Vigor Access Points
- Supports VigorACS 2 Central Management System for remote management
- 2 years back to base warranty

i-LAN TECHNOLOGY

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EDITORIAL

WELCOME TO ANOTHER ISSUE OF APC

Left to right: Chris Szewczyk, David Hollingworth, Ben Mansill, Joel Burgess, Dan Gardiner, Nich Richardson

EDITORIAL

APC TV

Presenting the Awards

We've just finished filming the first ever all-video Australian PC Awards, and you can watch it all over three parts on June 23rd, 24th and 25th at **www.australianpcawards.com.au**. Hopefully it all holds up well and our noobishness at presenting in a video format is mostly acceptable.

I thought it would be a good time now to more properly introduce the team you'll see. These are the guys primarily behind all the awards voting too, with the addition of two of our freelance writers covering their specialties Nick Ross (networking and storage) and Mark Williams (components and resellers), who weren't on camera that day.

Long-time *APC* readers will know former editor Dan Gardiner. Dan's still part of the *APC* team in the sense that here at Future Publishing we all row the boat and share our expertise. Dan knows PCs most deeply, and in his current role Dan leads the Australian editorial arm of Future Publishing as our Head of Content & Audience.

Joel Burgess is our laptop and PC reviewer, columnist, general things writer and the only surfer on this team of geeks. Not a month goes by here at *APC* when Joel doesn't carry the weight of delivering quality reviews based on careful testing and many years of accumulated perspective.

Chris Szewczyk is the name you'll see under most of *APC*'s component reviews. Chris is the type that lives and breathes motherboards, CPUs and video cards. His expertise is absolutely essential for *APC* to bring you reviews and features all about the heart of the PC, and of course keeping track of the always-changing landscape of technologies and the companies making the gear we end up buying and trusting.

You'll know David Hollingworth from our sister mag *TechLife*, as well as the many other sites and mags David's helmed for the last couple of decades. David's expertise is broad and there's very little he doesn't have something to say about.

And our MC for the Awards is Nich Richardson, who is a host for the ABC's *Good Game* as well as numerous other TV and live shows over the years. We asked Nich to be our MC because he genuinely knows and loves the PC and all its bits, and was able to bring a great energy and humour to the filming, making it all (I hope!) entertaining as well as informative.

Hope you enjoy it!

BEN MANSILL

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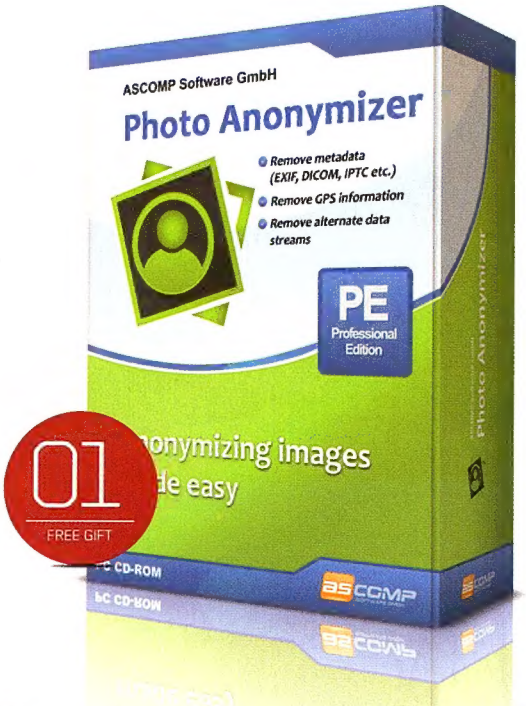

Exclusive downloads

How to download your free full-version programs.

Please note that these exclusive downloads will only be available for a limited time, from 14/06/21 to 01/08/21

ASCOMP Photo Anonymizer

Anonymise your image files by completely removing metadata and GPS information.

Often photos taken with a smartphone or digital camera contain personal information that not only disclose on the location and time of the recording, but can also hold other sensitive information. In so-called meta-tags, in addition to the GPS location, information about the recording device and even the photographer can be stored.

Photo Anonymizer helps you maintain your anonymity: Remove unclaimed metadata from your image files with just a few clicks! The free Windows software supports all common metadata standards, such as EXIF, DICOM, IPTC and XMP.

Did you know that Internet browsers often store the source of an image download in the respective file and thus can be traced for years to come, from which Internet address an image was downloaded? With Photo Anonymizer you can also completely remove these "alternate data streams"! Make sure that third parties no longer receive any information about which page you downloaded an image from!

Download link: **www.apcmag.com/exclusives**

Ashampoo Photo Optimizer 7

Ashampoo Photo Optimizer 7 auto-optimises photos at the click of a button.

Through extensive image analysis, weak points such as incorrect exposure, lack of contrast or incorrect coloring are detected and immediately fixed. Photos can be processed individually or in batches. Precision work can also be done: users can straighten image horizons, watermark images or apply numerous effects. Even minor blemishes such as red eyes, skin impurities or spots can easily be removed with this image editing software.

Furthermore, the highly effective built-in colour correction can quickly add an individual note to images or that classic realistic look. Free image rotation, cropping or straightening is also possible with ease. In addition, contrast, saturation and many other image aspects are adjustable through sliders with live previews for instant visual feedback. And thanks to the program's logical structure, user's don't need any training time as all functions are always no more than two clicks away. New in the program are the optimised interface, automatic white balancing, contrast stretching and completely revised image auto-optimisation technology.

Download link: **www.apcmag.com/exclusives**

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FUTURE

NEW VIDEO PRESENTATION FORMAT
Meet the team from *APC*, *TechLife* & *Techradar*

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It's time to discover the best of the best in tech

The 2021 Australian PC Awards is coming!

www.australianpcawards.com.au

Visit now to see all the finalists and check the viewing times to watch the Awards presentation streamed in three parts across **June 23rd, 24th and 25th**

THIS YEAR'S CATEGORIES:

Best Motherboard Maker
Best Value Motherboard
Best Premium Motherboard
Best GPU Maker
Best Value GPU
Best Premium GPU
Best Value CPU
Best Premium CPU

Best Internal Storage Maker
Best External Storage Maker
Best SOHO or Home NAS
Best Value Laptop or 2-in-1
Best Premium Laptop or 2-in-1
Best Gaming Laptop
Best Desktop PC Maker
Best Memory Maker

Best Cooling Product
Best Monitor
Best Keyboard
Best Mouse
Best Gaming Headset
Best PC Case
Best Router
Best Reseller

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CORSAIR crucial by Micron eset GIGABYTE msi PC GG
RAZER SAMSUNG SanDisk thermaltake WD

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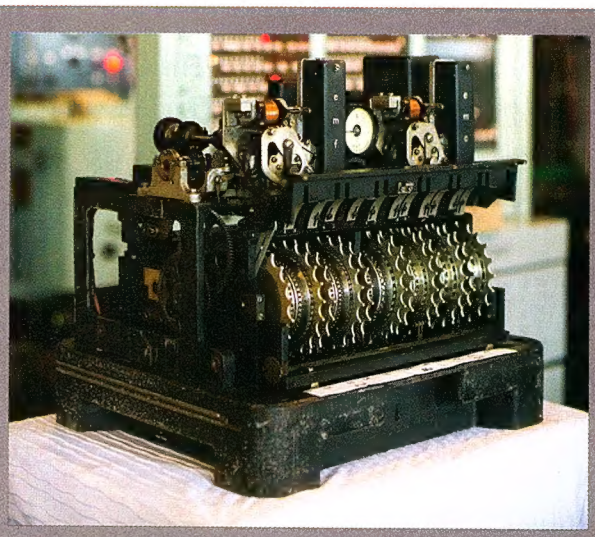

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A COLOSSAL SECRET

Ian Evenden discovers how British WWII braniacs, faced with an impossible task, helped save millions of lives and invented the computer as we know it. **Page 52**

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The less than serious news page

Inside *APC*

Find out all about *APC*'s editorial policies, test practices, how to read the benchmark results, and more.

APC is Australia's oldest consumer technology magazine – having been consistently in print for forty years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, and beyond. We have two goals: to find the best modern tech and to help you make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And, like you, *APC*'s journalists want to know what's good in tech – no matter what platform it resides on.

Independent reviews

Championing technology doesn't mean we're unrelenting yes-men and -women, however, and *APC* aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three attributes.

As a matter of policy, reviews published in *APC* are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an *APC* reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

Labs testing

APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance including storage read and write speeds, gaming and battery life.

In most cases, for the benchmark results published in *APC*, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter offers better ease-of-readability, but tables are more compact, so we use these in most cases where thoroughness is preferred.

APC testbed

The current *APC* testbed used in the Labs for benchmarking all components. This testbed is updated as new and relevant technology comes on stream.

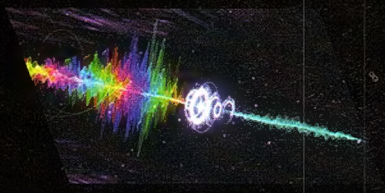
CPU	AMD Ryzen 7 5800X
Motherboard	Asus ROG Crosshair VIII Dark Hero
GPU	MSI GeForce RTX 3080 Gaming X Trio
Memory	2x8GB Team T-Force Xtreem ARGB DDR4-3600
Primary SSD	Adata S70 2TB NVMe
Secondary SSD	Samsung 980 Pro 500GB NVMe
Cooling	Nzxt X73 360mm AIO
Case	Thermaltake Core P8
Power Supply	Corsair AX1000

REPUBLIC OF GAMERS

THE CHOICE OF CHAMPIONS

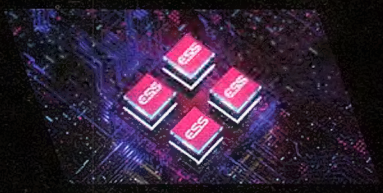
ROG DELTA S

DOMINATE WITH SUPERIOR SOUND



AI Noise-Canceling Microphone

Designed for crystal-clear in-game voice communication.



High-Resolution ESS 9281 Quad-DAC

Technology that provide lossless audio processing

Built in MQA Renderer

Award-winning audiotechnology that delivers impeccably detailed, true-to-life audio

DISCORD CERTIFIED

teamspeak CERTIFIED

Hi-Res AUDIO

MQA

ASUS

TECHNOTES

ALL THE NEED-TO-KNOW TECH NEWS

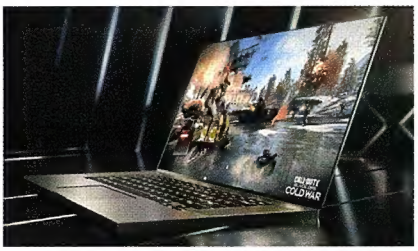
Gigabyte apologises for 'Made in China' comment after losing $710 million

Several marketplaces had removed its products.

Gigabyte has apologised for a comment it made about Chinese manufacturing that prompted social media outrage, led several marketplaces to remove its products from their platforms, and caused a $710 million drop in its market value.

According to *Bloomberg*, the company published a blog post slamming its competitors for outsourcing production to Chinese manufacturers that make products in a "low-cost, low quality way." The blog post has since been deleted.

That comment was seen as an indictment of Chinese manufacturing writ large instead of a targeted criticism of Gigabyte's rivals – which is what prompted the removal of its products from the JD.com and Suning.com e-commerce platforms. All of which led Gigabyte to publish an apology for that blog post.



Nvidia RTX 3050 Ti GPU

Performance, specs, availability, and more.

Nvidia's still eager to pump out GPUs that most gamers will have a hard time getting hold of, as is the case with its latest mobile GPU, the RTX 3050 Ti. Its debut officially puts the nail in the coffin of the GTX 1650, Nvidia's previous mainstay budget GPU for low-end gaming laptops.

Nvidia gives a few examples of how the RTX 3050 Ti and GTX 1650 will differ. In *Call of Duty: Warzone*, the 1650 can manage 55-ish FPS at medium settings at 1080p with an Intel Core i7 processor. With the same config, a 3050 Ti can output FPS counts in the low 80s, escalating to just under 100 if DLSS is enabled. Basically, under the right circumstances, performance is almost doubled when going from a 1650 to 3050 Ti.

LAPTOP CPUS

Intel launches eight-core Tiger Lake-H processors

Higher power consumption, lower clocks.

Intel introduced its long-awaited eight-core Tiger Lake-H chips for laptops, marking Intel's first shipping eight-core 10nm chips for the consumer market. These new 11th-generation chips, which Intel touts as the 'World's best gaming laptop processors,' come as the company faces unprecedented challenges in the laptop market – not only is it contending with AMD's increasingly popular 7nm Ryzen "Renoir" chips, but perhaps more importantly, Intel is also now playing defence against Apple's innovative new Arm-based M1 that powers its new MacBooks.

The halo eight-core 16-thread Core i9-11980HK peaks at 5.0GHz on two cores, fully supports overclocking, and despite its official 65W TDP, can consume up to 107W in base mode and 135W under heavy load in high performance mode. Additionally, Intel has also added limited overclocking support in the form of a speed optimiser and unlocked memory settings for three of the 'standard' eight-core models.

As with Intel's lower-power Tiger Lake chips, the eight-core models come fabbed on the company's 10nm SuperFin process and feature Willow Cove execution cores paired with the UHD Graphics 750 engine with the Xe Architecture. These chips will most often be paired with a discrete graphics solution, from Nvidia or AMD.

All told, Intel claims that the combination of the new CPU microarchitecture and process node offers up to 19 percent higher IPC, which naturally results in higher performance potential in both gaming and applications. That comes with a bit of a caveat, though – while Intel's previous-gen eight-core 14nm laptop chips topped out at 5.3 GHz, Tiger Lake-H maxes out at 5.0GHz. Intel says the higher IPC throws the balance towards even higher performance regardless of 10nm's lower clock speed.

Intel says the new Tiger Lake-H chips will come to market in 80 new designs (15 of these are for the vPro equivalents). Surprisingly, Intel says that it has shipped over 1 million eight-core Tiger Lake chips to its partners before the first devices have even shipped to customers, showing that the company fully intends to leverage its production heft while its competitors, like AMD, continue to grapple with shortages. Intel also plans to keep its current fleet of 10th-Gen Comet Lake processors on the market for the foreseeable future to address the lower rungs of the market, so its 14nm chips will still ship in volume.

"Intel claims that the combination of the new CPU microarchitecture and process node offers up to 19 percent higher IPC."

Intel Tiger Lake-H and competitors

PROCESSOR NUMBER	BASE / BOOST	CORES / THREADS	L3 CACHE	MEMORY
CORE I9-11980HK	2.6 / 5.0	8 / 16	24 MB	DDR4-2933 (GEAR 1) / DDR4-3200 (GEAR 2)
AMD RYZEN 9 5900HX	3.3 / 4.6	8 / 16	16 MB	DDR4-3200 / LPDDR4X-4266
CORE I9-10980HK	2.4 / 5.3	8 / 16	16 MB	DDR4-2933
CORE I7-11375H SPECIAL EDITION (H35)	3.3 / 5.0	4 / 8	12 MB	DDR4-3200, LPDDR4X-4266
CORE I9-11900H	2.5 / 4.9	8 / 16	24 MB	DDR4-2933 (GEAR 1) / DDR4-3200 (GEAR 2)
CORE I7-10875H	2.3 / 5.1	8 / 16	16 MB	DDR4-2933
CORE I7-11800H	2.3 / 4.6	8 / 16	24M	DDR4-2933 (GEAR 1) / DDR4-3200 (GEAR 2)
CORE I5-11400H	2.7 / 4.5	6 / 12	12 MB	2933 (GEAR 1) / DDR4-3200 (GEAR 2)
RYZEN 9 5900HS	3.0 / 4.6	8 / 16	4 MB	DDR4-3200 / LPDDR4X-4266
CORE I5-10400H	2.6 / 4.6	4 / 8	8 MB	DDR4-2933

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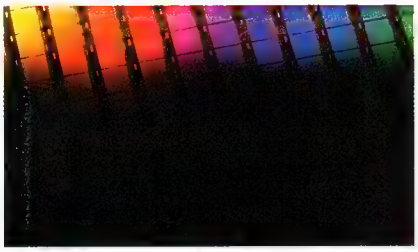


Pic: Micron

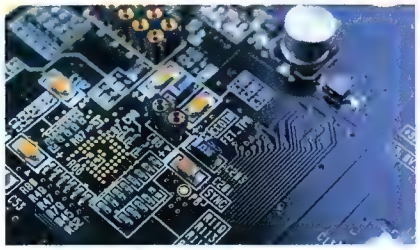
Memory price hikes are coming

Get it while you can.

High demand for PCs and, importantly, desktop PCs has already resulted in increased graphics card, PSU, HDD, and SSD pricing, but apparently, now DRAM is getting even more expensive, too. According to a new report from Taiwan, memory prices are set for double-digit growth in the coming months.

Contract memory prices are projected to increase by 10 - 20 percent, *DigiTimes* reports. According to the report, memory prices may rise by up to 25 percent, depending on the kit. Keeping in mind that demand is high and DRAM is transiting to DDR5 memory, the increase is not surprising.

DRAM quotes are not alone when it comes to price hikes. Prices of NAND memory have also increased by 10 percent so far this year.



Pic: Shutterstock

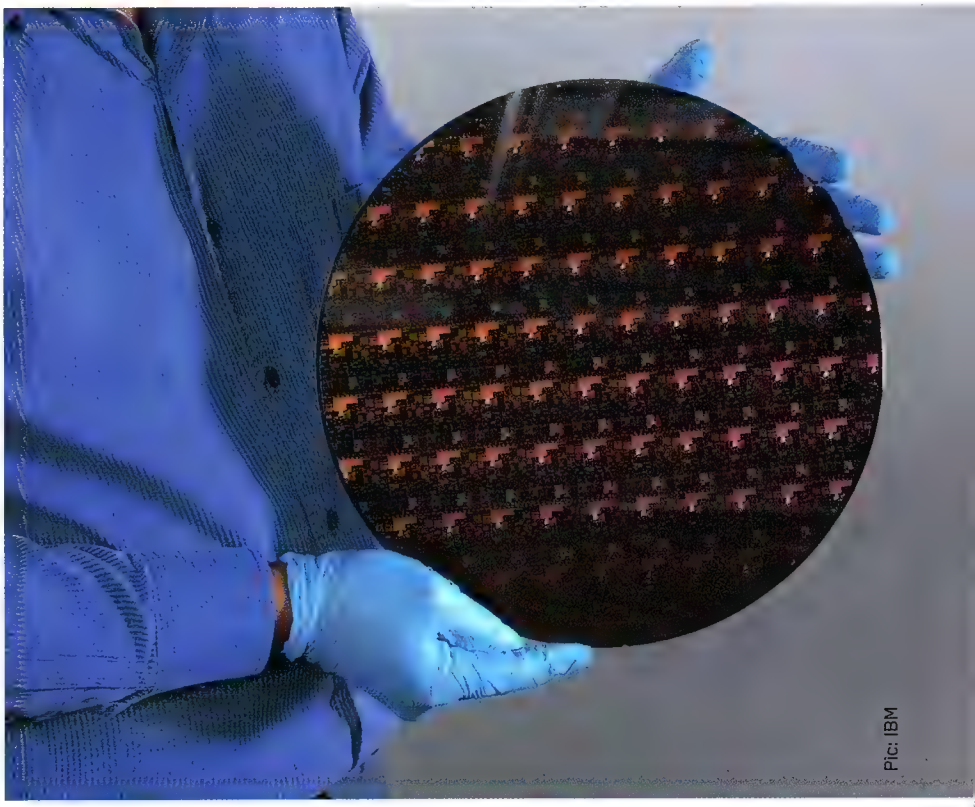
Microchip substrate shortage is expected to end by 2022

AMD, Intel, and Nvidia are all desperate for more supply.

AMD, Intel and Nvidia could see chip production ramping up within a few years, thanks to increased substrate supply. That's because, according to *DigiTimes*, global supplies for the ABF substrate industry are expected to improve sometime in late 2021 or 2022 as substrate manufacturers based in Taiwan and China start bringing additional capacity online through more plants and production lines.

ABF substrate material is incredibly important for the semiconductor industry as it is responsible for connecting microchips to their associated circuit boards. Recent substrate shortages are partially to blame for the CPU and GPU shortages we've been seeing over the past few months.

AMD, Intel, and Nvidia have also been busy, securing more and more capacity from substrate manufacturers to help improve the lack of supply.



Pic: IBM

CHIP TECH

IBM unveils world's first 2nm chip with nanosheet tech

Intel and Samsung to benefit.

IBM research unveiled a new 2nm chip with nanosheet technology that will serve as the underpinning of its future process technology. IBM displayed a full 300mm wafer produced on the 2nm nanosheet process at its Albany, New York facilities. However, it is important to remember that the technology is still in the research phase, so the wafer doesn't have productisable chips, at least in their current form.

IBM no longer mass-produces processors; instead, it helps develop technology for its partners, like Intel and Samsung. The former recently announced that it would research new process node and packaging technologies with IBM as part of its new IDM 2.0 initiative. That means that Intel's future 2nm chips could be based on some of these IBM breakthroughs.

IBM claims that the new process node tech will improve performance by 45 percent using the same amount of power or 75 percent less power while maintaining the same performance as today's 7nm processes. IBM says the new chips will feature up to 50 billion transistors in a chip the 'size of a fingernail'.

Microsoft is killing Internet Explorer 11

Microsoft Edge will take on all the duties.

Microsoft is finally kicking the curb to its once-famous and popular Internet Explorer web browser. In a recent blog post, Microsoft said that it plans to fully retire Internet Explorer 11 (the latest version of the browser) by June of 2022. For companies still using apps tailor-made for Internet Explorer, Microsoft has added an Internet Explorer compatibility mode to Edge, to ensure critical enterprise apps remain operational.

Back in the early 2000s, Internet Explorer was actually one of the best browsers on the web and supported cutting-edge technologies that no other browser supported. But, due to Microsoft's persistent use of proprietary APIs and lack of consistent updates, Internet Explorer quickly lost ground to other web browsers like Chrome and Firefox in the early 2010s. ■

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TECH BRIEF

AMD CEO Lisa Su not too worried about the chip shortage

It's just a megacycle.

AMD CEO Dr. Lisa Su doesn't seem all that worried about the global chip shortage. In fact, she said in an interview with *Bloomberg* that this is just a "megacycle" the semiconductor industry has to go through. It's the type of thing she says she has watched the industry go through similar periods of demand far outpacing supply throughout her career.

"Semiconductors do go through these cycles," she said. "There are some times when supply is much greater than demand, and there are some times when demand is much greater than supply. And this particular cycle is special because what we're seeing is the incredible demand for all things that require chips [across markets]."

That isn't hyperbole. The ongoing chip shortage has affected the availability of everything from automobiles and display drivers to graphics cards and single-board computers. It's reached the point where Newegg is holding raffles with a fraction of a percent chance of receiving the opportunity to buy – not win – the latest hardware.

"Yes, it's a lot to manage," Su said of the chip shortage in her interview with *Bloomberg*. "But I have to tell you, this industry is also really good at managing these things. And you know, it does take a while for the supply and demand imbalance to balance itself out, but we are very much working together as an industry."

Some of those efforts include AMD and Intel investing in substrate production and essentially every large tech company joining the Semiconductor Industry Association Coalition to secure US$50 billion from the U.S. government to support the American chip industry (not to mention AMD's promise to up production of its own products).

As for when the chip shortage ends and companies run the risk of having oversupply problems, well, it doesn't seem like Su is particularly worried about that either.

"I think what's important [is] the strength of the product portfolio, the markets we're addressing," she said. "At AMD we've chosen markets that we think are very resilient. Everyone is going to need more computing whether it's this year, 2022, 2023. We just think computing is one of those trends that you're going to need more of. So we've been investing in those types of areas. My view of the world is that it's important to have the right products, it's important to be in the right markets, and then of course executing well along the way."

We expect these kinds of assurances from semiconductor executives, of course, because it's better to project stability than to make it seem like the company is going to struggle to respond to a situation that's likely to repeat itself in the future. But it's still remarkable to watch Su make it seem like everything's fine despite this struggle.

Su was similarly poised when she discussed the chip shortage at CES 2021 in January, and if this interview's any indication, don't be surprised if she delivers a similar message during her Computex 2021 keynote. ■

"The ongoing chip shortage has affected the availability of everything from automobiles and display drivers to graphics cards and single-board computers."

Confidence is high at AMD, and CEO Dr Lisa Su remains optimistic for an end to the shortages soon.

Pic: AMD

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END USER

Switch saved handhelds, now Valve wants in on the action

Thought to be on the decline, handheld gaming seems to be undergoing a revival.

The Nintendo Switch has sold over 78 million units as of 2020, completely overshadowing its predecessor the Wii U, which sold a measly 13.5 million and is widely considered a failure. While it's marketed as an all-round home console, the Switch's portability is the chief appeal for most players: it inherits all of the non-gimmicky qualities of the old DS line, while offering a huge library of third-party titles, HD gaming and simple compatibility options.

That latter part is key: Sony's PS Vita tanked for a lot of reasons, but one of these was that it was weighed heavily by its expensive proprietary connectivity. Want to expand storage? Sorry, you'll need to pay through the nose for one of Sony's expansion cards. Want to charge it on the go? Make sure you don't lose your unique charger, which is expensive to replace. The Switch takes any old micro SD card and can be charged anywhere using USB-C. Easy.

This grubbing affection for proprietary guff is probably not what killed the Vita, but it made it a real pain in the arse. Seamless, convenient, fun handhelds can prosper, Nintendo has proven, and it looks like Valve has been paying attention. Last month its SteamPal handheld leaked, and while it lacks Nintendo brand power, the concept alone is promising. According to the leaks, it runs on Linux, boasts a touchscreen, gamepad and a "system on a chip" approach to its innards. The leaks also suggest easy USB connectivity with large screens.

It's promising: Valve has invested a lot in Linux these past few years, and its Steam Play tool allows Windows games to run using its Linux client – that's one big obstacle out of the way. It already has a UI in the form of Steam Big Picture mode (naturally, that will need an overhaul), and, well, the market for a SteamPal already has an extant Steam library, assuming access to that library is part of the offer – it'd be silly if it wasn't.

Of course, a handheld isn't going to run blockbuster titles at optimum performance, but that's where Steam Remote Play comes in – in-home streaming of, say, *Assassin's Creed Valhalla* on a monster PC, straight to your handheld, is no doubt part of the dream. Of all of Nintendo's platform competitors – Sony, Microsoft, and PC (ie, Valve) – the latter seems best equipped to issue a handheld that could take off. Steam is absolutely lousy with useful functionality, such as Remote Play Together, which basically makes every Steam local multiplayer game an online game by default.

Valve doesn't have the best reputation when it comes to hardware initiatives, though: Steam Machines never took off, mostly because they couldn't nail the mass market ease of a console experience (and also because they were prohibitively expensive). The Steam controller, meanwhile, has its fans but is incredibly niche and anyway now discontinued. But if Valve wants to make the SteamPal a success it has the very best role model to ape – Nintendo – and frankly, all the tools at hand to better it. As always, the market will decide, but the market does love *Valheim*, maybe even more so while on the shitter. ■

SHAUN PRESCOTT
Author, PC Gamer editor and passionate technology observer, Shaun covers trending tech topics for *APC*.

"A handheld isn't going to run blockbuster titles at optimum performance, but that's where Steam Remote Play comes in – in-home streaming of, say, Assassin's Creed Valhalla on a monster PC, straight to your handheld, is no doubt part of the dream."

"Tim Cook even publicly rebuked Facebook founder and CEO Mark Zuckerberg in 2019 for not prioritising its customers' privacy by deleting extraneous user data... a comment that looks a little rich now that it's emerged that Apple has spent the last few years being bullied into restructuring its Chinese operations to circumvent US laws prohibiting it from sharing user data with the Chinese government."

Apple's 'Golden Gate' project delivers user data to the Chinese government

Apple has built a strong reputation on user privacy, but Joel Burgess wonders whether the company is having to backpedal on these ethics.

Apple has long touted the importance of privacy across its devices, going so far as to secure advertising billboards in Vegas' most prominent positions ahead of the 2019 CES stating "What happens on your iPhone, Stays on your iPhone". Since 2016, the tech company has also fought a number of high profile requests from the FBI to create a backdoor into its devices for the US government on the grounds that backdoors create privacy vulnerabilities that can be exploited by more than just law enforcement. Tim Cook even publicly rebuked Facebook founder and CEO Mark Zuckerberg in 2019 for not prioritising its customers' privacy by deleting extraneous user data... a comment that looks a little rich now that it's emerged that Apple has spent the last few years being bullied into restructuring its Chinese operations to circumvent US laws prohibiting it from sharing user data with the Chinese government.

A recent article by the *New York Times* details the Cuppertino company's long road to ceding control over user data in China, a process that began all the way back in 2016 following the announcement of a national data law that stated all "personal information and important data" produced in China was required to remain in China. This law came into effect in June 2017 and although Apple pushed back to keep the data in the US, the company's local employees warned that the Chinese government would likely shut down iCloud if Apple did not move this data to local servers. Since the US has laws that prevent American companies from sharing data with the Chinese government, Apple arranged for all local data to be transitioned into the hands of Guizhou-cloud Big Data (GCBD), a company owned by the government of Guizhou province.

All iCloud data is encrypted and while the data might be held on government owned hardware, it still requires a key to access, something that Apple was able to hold onto for another eight months after the data centre transition. The *New York Times* was not able to discern why these keys were eventually passed over to the Chinese government in 2018, but Apple's $55 billion dollar local annual revenue and largely China-based manufacturing operation put the company in a uniquely vulnerable position.

While this is a considerable backflip on the privacy stance it actively promotes in the rest of the world, critics argue that Apple's relationship with the Chinese government makes it complicit in a much broader remit of local censorship behaviour as well. The Asia Director of Amnesty International, Nicholas Bequelin said to *The Times*, "Apple has become a cog in the censorship machine that presents a government-controlled version of the internet".

JOEL BURGESS
When not reviewing PCs for *APC* and writing our funny pages, Joel likes to ponder tech and how it's used.

Apple admitted it approved 1,217 demands by the local government to remove specific applications from the app store in the two years prior to June 2020, a figure roughly five times the number of apps removed at the request of every other nation's government over that period. This figure is just a fraction of the 55,000 odd apps that *The Times* estimates have been removed from the App Store in China since 2017. 600 of these are supposedly news related, but Apple only acknowledges that 70 news apps were removed at the request of the government, a discrepancy that is explained by Apple's internal app removal policy that, according to the former head of the App Store, Philip Shoemaker, required automatic removal of any apps the company believed to be 'off-limits' in China. ■

TWO BITS

Budget SSDs are commodity items

Flash drives are probably sexier.

SSDs are everywhere. Even the cheapest laptops and systems have ditched mechanical storage, and all but the cheapest refurb runout models come with an M.2 SATA or NVMe SSD. Though there are M.2 drives with eye catching heatsinks and even RGB lighting, most of them are bland. They're there to do a job out of sight and out of mind, buried inside a laptop or under a motherboard heatsink, never to be seen. They are, frankly, boring.

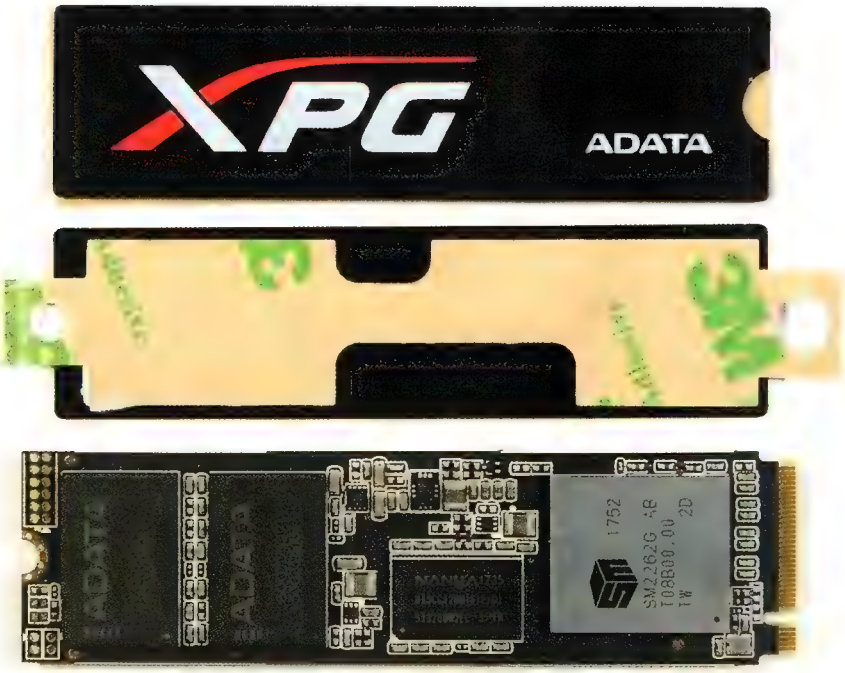
There's little to differentiate budget models from one another. SSD makers continue to promote sequential read and write speeds as the be all and end all. Fast sequential performance is a good characteristic to have, but it's the IOPS, latency, and random performance that provide the responsiveness we all take for granted. Does the average user care if a 10GB transfer takes two seconds or three? Probably not, and anyway, those maximum speeds require very fast source and destination drives that most systems typically wouldn't have.

I reviewed the Kingston NV1 in this issue. I actually struggled to find a lot to say about it as when I asked, Kingston declined to disclose key specifications in order keep open the option to change things like the flash or controller in the future. We understand the reasoning for this, but it also takes information away from the consumer. Adata recently took a black eye for altering the components of its SX8200 drive mid-life, which resulted in a performance hit. A modern cheapie SSD isn't all that much different from a flash drive. There just isn't much to know about them anymore. Entry-level NVMe SSDs are now primarily differentiated by price, capacity and to a lesser extent, warranty.

CHRIS SZEWCZYK
A life-long PC tech enthusiast, Chris has worked acoss the industry in many areas as a product and technology expert.

This means flash drives and budget SSDs are essentially commodity items. They are easily interchangeable. You're really not going to notice the difference between drive A at $100 and drive B at $105. If the $105 drive comes with a better endurance rating and a longer warranty, then that's the drive you should go for. Will most users care though? Many will take the $5 saving.

Most buyers of affordable laptops and systems probably don't know much, if anything about the drive in their system other than its capacity. A Kingston or a Samsung or a Crucial drive is all the same to them. A discussion around enticing this kind of user to upgrade isn't going to go far beyond adding capacity. As enthusiasts, we want to know more about what's under the hood in our systems. Performance still matters at the high end as does endurance, reliability, aesthetics and things like the software package or encryption support. However, it's becoming increasingly difficult to differentiate between budget drives. Reviewing them isn't very revealing, and marketing them must be even harder. NVMe SSDs are essential components, but let's face it, the entry level ones are pretty boring, much like a DDR4-3200MHz kit is beyond its look and price. If you're strictly looking for a budget drive, you might as well go for one that offers a good price-per-GB or perhaps a five-year warranty vs a three-year one. Do you go for a Kingston NV1 or a Crucial P1? How about a WD SN550? Whatever's on special that day? That kind of interchangeability is what defines a commodity product. ■



"Fast sequential performance is a good characteristic to have, but it's the IOPS, latency and random performance that provide the responsiveness we all take for granted. Does the average user care if a 10GB transfer takes two seconds or three?"

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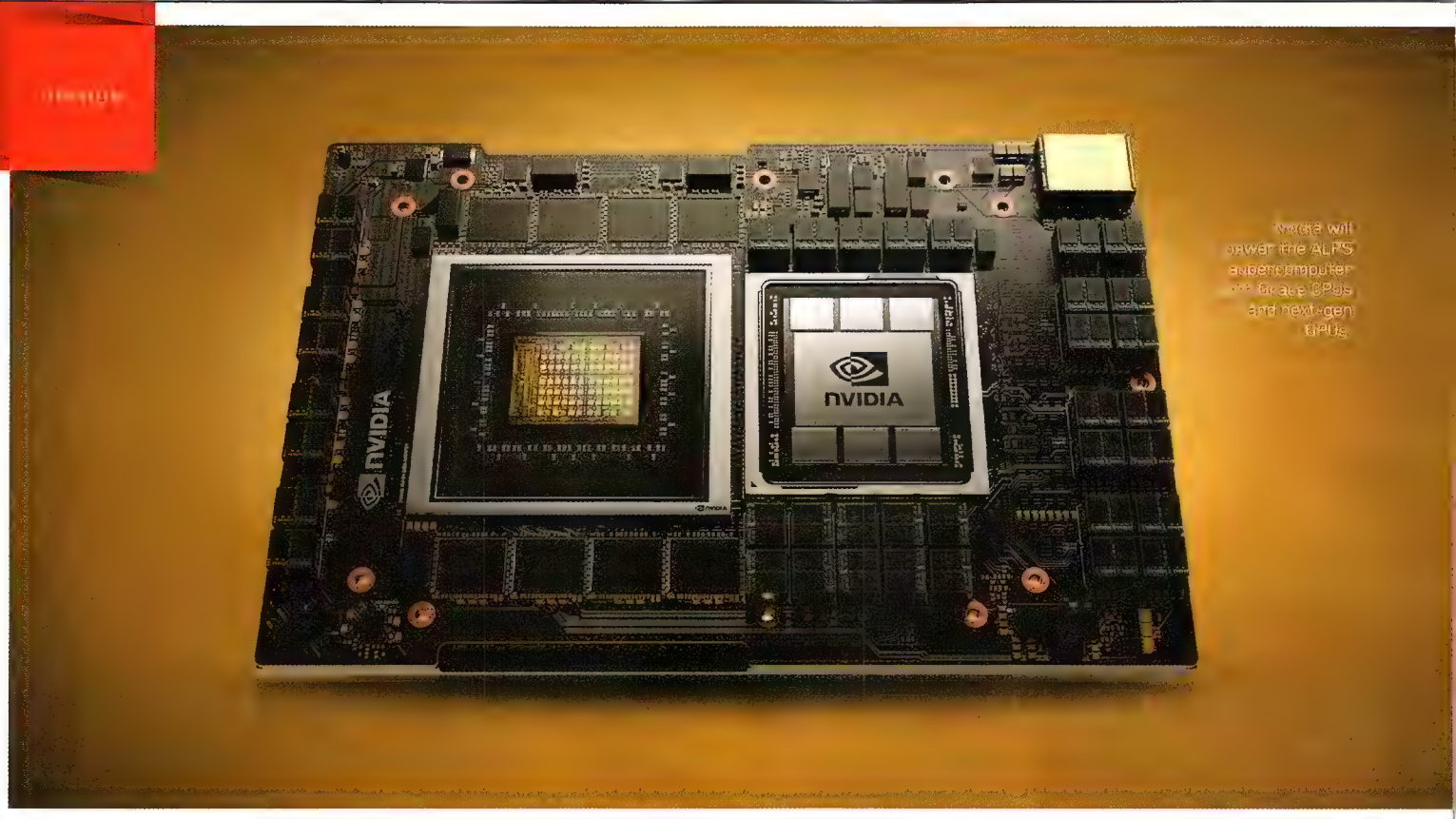


Nvidia will power the ALPS supercomputer with Grace CPUs and next-gen GPUs.

TECH TALK

Nvidia's Grace CPU

Another step towards ARM ending the x86 era?

When Nvidia announced it was buying ARM, the intent was clear: Nvidia wanted a way to compete in the CPU space. That's set to happen in 2023 with the arrival of the Grace CPUs. It's still a way off, but the specs already look impressive. The ARM acquisition paves the way for Nvidia to attempt to do in the CPU space what it's been doing with GPUs for over 20 years.

A decade ago, we first heard about Project Denver, a CPU architecture that would use binary translation to provide x86 compatibility. Intel blocked the x86 compatible aspect, but the chip did see the light of day in a few products, such as the Nexus 9 tablet. With the rise of ARM processors that power nearly all phones and tablets, plus some laptops and even servers, x86 compatibility is a must-have no more.

Grace focuses on Nvidia's strong points: AI and deep learning. The company claims it delivers 10 times more performance than the fastest servers, at least in AI and HPC workloads. That will almost certainly come via vector extensions that boost performance in matrix computations, but Grace will also boost higher bandwidth and efficiency, thanks to LPDDR5x, and promises some of the fastest interconnects between CPUs and GPUs via NVLink: over 900GB/s cache coherent CPU-to-GPU NVLink, and more than 600GB/s CPU-to-CPU.

Nvidia hasn't talked core counts or clock frequencies yet, and while the rendered image suggests it might have 96 CPU cores, it's likely just a placeholder. Prior to the Nvidia acquisition, ARM had already disclosed its future high-performance Zeus CPU cores, which likely play a role in Grace given the time frame, though Nvidia now calls these ARM Neoverse cores. The ARM V1 platform includes support for all the latest whiz-bang tech: PCIe Gen5, DDR5, HBM2e or HMB3, and a CCIX 1.1 interconnect. Swap out CCIX for NVLink and link the CPU up with an Ampere Next GPU, and you have a potent starting point for a supercomputer node that can scale up to thousands of nodes.

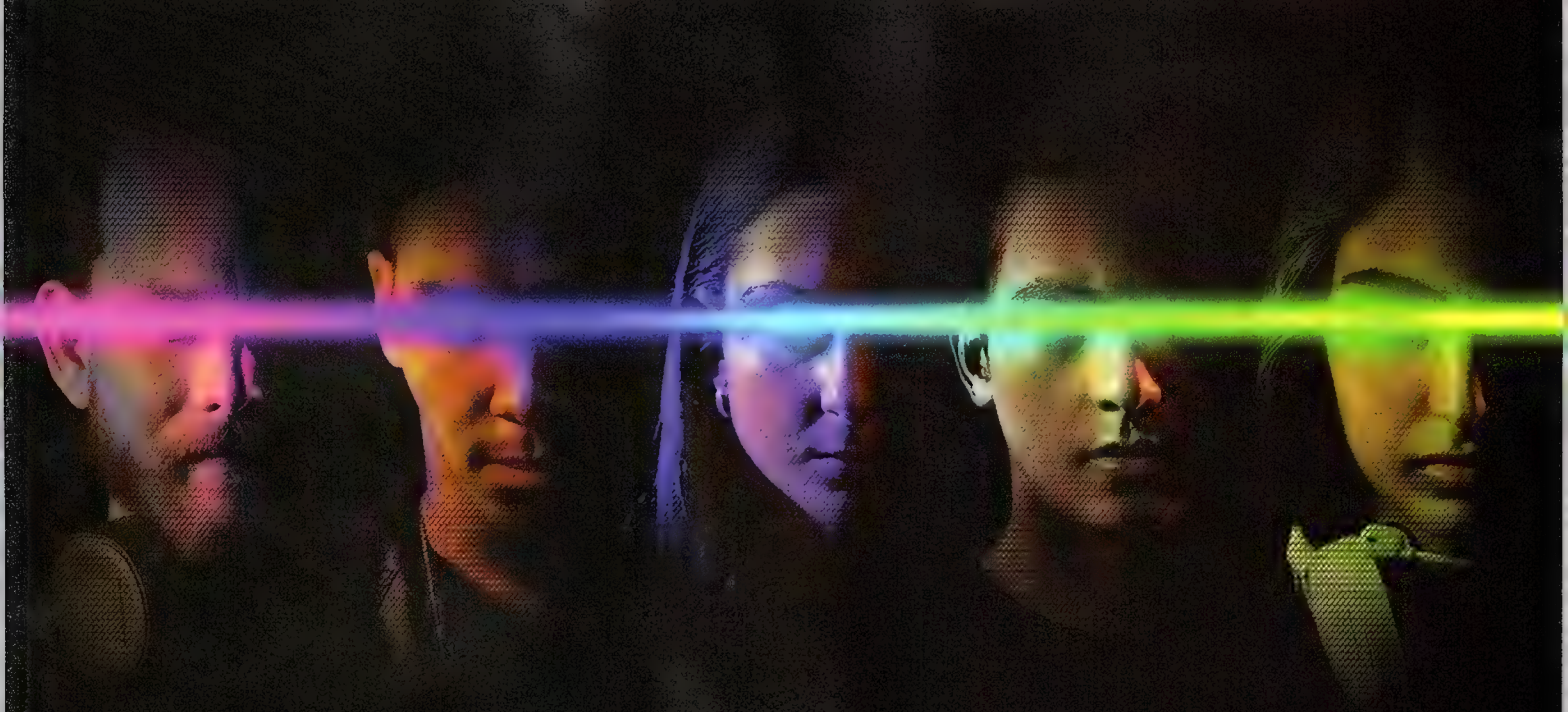
Incidentally, the CPU is named after Grace Hopper, one of the pioneers of computer programming. Current indications are that Nvidia's post-Ampere GPU architecture will be code-named Hopper, so it will combine CPUs and GPUs to give double honours.

Perhaps more interesting is where else we might see the Grace Hopper combo show up. It's a safe bet that Nvidia's plans don't end with supercomputers. Look at the laptop world and Nvidia already discusses that as an almost entirely separate market from desktop gaming PCs. We've also seen a few laptops testing the Windows on ARM possibilities – and, of course, there's Apple's M1 that eschews Windows and x86 in favour of an all-Apple design.

Officially, there's no word of consumer variants of Grace or Hopper yet, but we know they're coming. Nvidia still has its roots in the gaming market, and building a better gaming laptop – one that can play games untethered for many hours – would be impressive. Getting game developers to jump ship from x86 to ARM would have been practically unthinkable five years back, but with Nvidia, Apple, and others involved, it becomes less a matter of "if" and more "when" we'll see high-end gaming laptops running all-Nvidia processors. ■

"Nvidia hasn't talked core counts or clock frequencies yet, and while the rendered image suggests it might have 96 CPU cores, it's likely just a placeholder."

JARRED WALTON
Jarred Walton has been a PC and gaming enthusiast for over 30 years.



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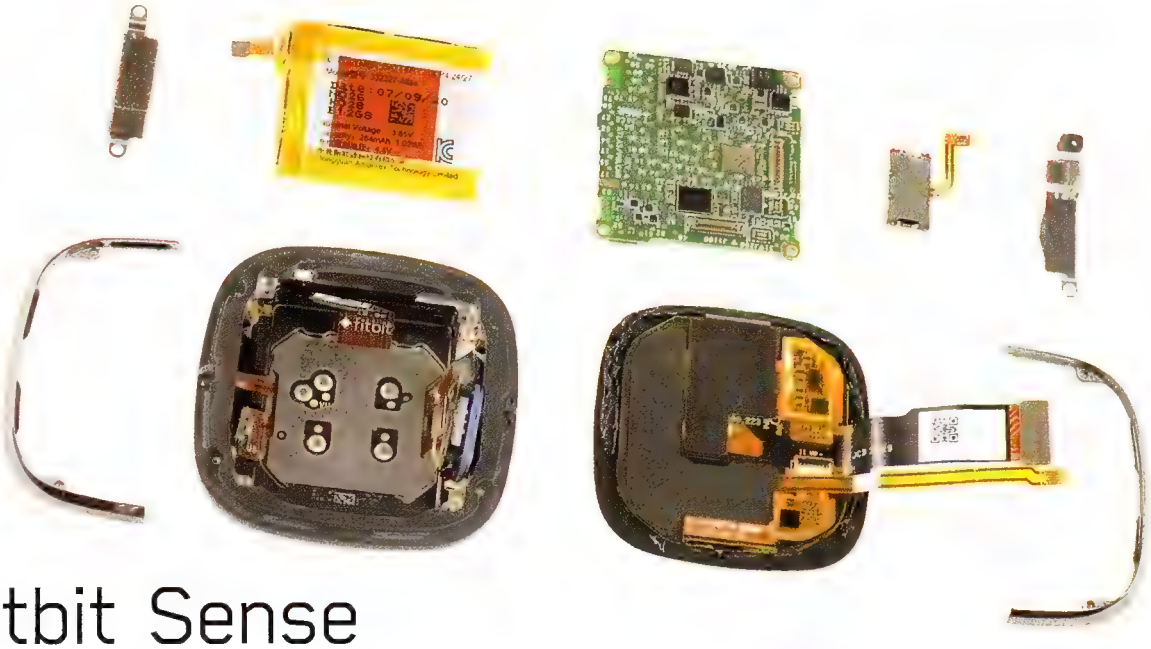


Fitbit Sense

Fit for scheduled disassembly.

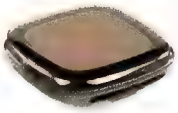
The new Fitbit Sense competes against the Apple Watch Series 6, but what happens when the Fitbit gets sick? Well, that's why we're here today – to determine how difficult the surgery will be.

Major tech specs

- 1.58-inch AMOLED screen
- 4GB internal storage
- A new ECG function as well as a skin temperature sensor, and the standard optical heart rate sensor
- Wi-Fi, NFC, Bluetooth 5.0, and built-in GPS
- Water resistant up to 50 meters
- Also part of the package are a gyroscope, altimeter, three-axis accelerometer, and ambient light sensor

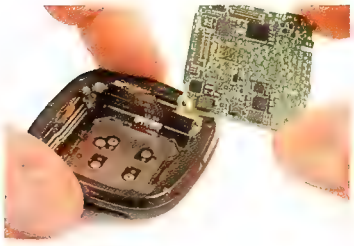
Key findings

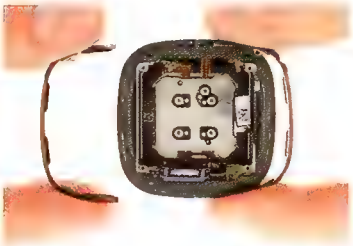
- Like the Apple Watch, the Fitbit Sense's ingress protection means the very thin gap between the display and the housing of the watch is lined with adhesive. Even with a heat gun and extremely thin prying tools, it is difficult to get the display to budge. A semi-unprotected OLED display underneath the glass and booby trap cables near the edge add to the challenge. Though it is precariously placed, the display cable is long enough to allow us to lift the screen with ease once the hard part is done. Underneath we're greeted by a small bracket fastened with tiny T2 Torx screws covering the connectors we need to disconnect – no problem for our Pro Tech Toolkit.
- The motherboard doesn't come out alone – the battery hitches a ride, lightly adhered to its underside. The battery is a 1.02Wh (266 mAh @ 3.85V) cell, slightly less potent than the 1.17Wh cell of the Apple Watch Series 6, and a far cry from the 2.16Wh cell in the Xiaomi Watch. We get the sense that this Fitbit is considerably less complex than any Apple Watch. That's good for these repairs – battery, board, and screen are all accessible within a few steps!
- Two more brackets tucked up against the sides of the housing keep a few more key components in place: loudspeaker and pressure sensor on one side, and a microphone, vibration motor, and pseudo-button on the other. Apart from the vibration motor, all of these components connect to the sensor board at the bottom of the housing and terminate in soldered connections. It's unlikely you'll be able to remove it without damaging something. The edge around the display features two separated metal brackets for reading your EDA levels (electrodermal activity) and taking that ECG.
- While the opening procedure is far from ideal, most of the critical components in this Fitbit are accessible and replaceable, and disassembly is very straightforward. Unfortunately, some components are integrated into the sensor board, which is fastened with permanent adhesive. Let's wrap up this quick teardown with a score…
- Repairability Score: 5 out of 10 (10 is easiest to repair). Watch bands are easily replaceable (though not standard issue). Standard screws are used prudently throughout the device. The display-first disassembly procedure means screen replacements require only a few steps, but those steps are difficult, and can easily damage the display. The battery is buried under the main board, but it can be disconnected immediately upon opening the watch, and is easy to remove once you get to it. Components underneath the battery aren't modular, and will be very difficult to remove because of their strong adhesive. ■



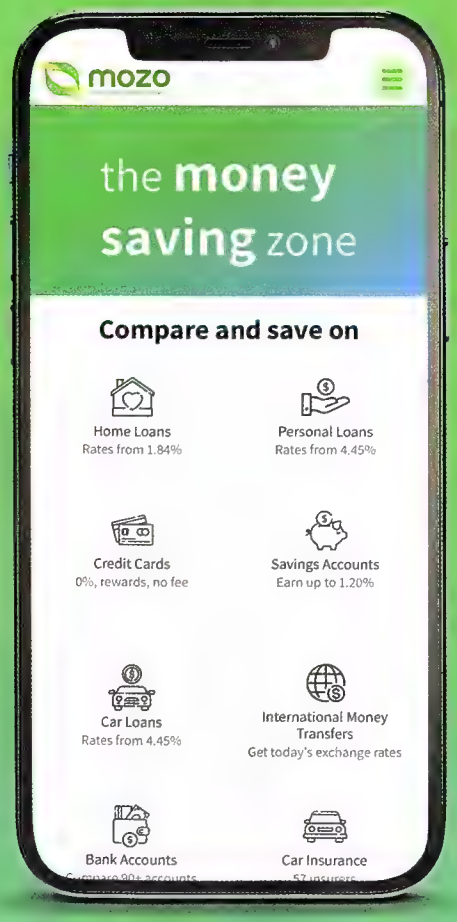
Riddled with sensors and health features, the new Fitbit Sense is poised to rival the Apple Watch Series 6 as a health-focused wearable device.

Lots of heat and careful prying needed to open up this watch.





Far Left: Torx screws and connectors attach the motherboard. **Left:** Even if you're handy with a soldering iron, everything is locked in with some serious adhesive.



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The money saving zone

GADGETS

TECHY TOYS THAT MAY OR MAY NOT INSPIRE JOY

$79 | amazon.com/au

Govee Immersion WiFi TV Backlights

A big splash of immersive colour.

This is a cheap and effective way to cast the RGBs from behind your TV onto a wall, with dynamic colours based on what's happening on-screen. The kit contains a long enough RGB strip to cover three edges, which is stuck in place behind your TV. Instead of taking a feed from the source, like the Philips Hue solution, the Govee kit has a camera that's placed at the top or bottom of your screen that watches TV with you, and changes the colours via a controller box. There's an app for selecting modes if you don't want it synced, and instead want a mess of disco lightning. It's a very elegant and cost-effective solution and the effect is absolutely delightful.

$299 (32GB), $139 (16GB) | hyperxgaming.com

HyperX Fury RGB

A civilised dose of RGB.

We recently needed to upgrade one of the *APC* testbeds with new memory, and wanted something a bit fancy – but were also constrained by clearance issues caused by an over-sized CPU cooler. After some looking around and measuring we settled on this HyperX Fury RGB kit. The low profile allowed easy fitting – a key factor as many RGB-adorned memory kits are invasively tall. We also really liked the relatively simple light strip, which now looks fine in our all-red box. Credit too, to the HyperX Ngenuity app; it's simple and unlike many RGB controller apps doesn't remind you of its existence via pop ups every day.

US$1,470 | kck.st/2PhMwDB

Yaw 2

This VR gaming chair looks Yawsome!

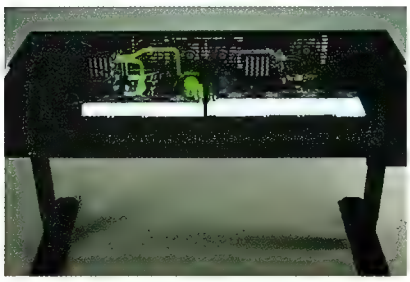
With over $2 million dollars in funding with more than two weeks to go, this VR motion chair well and truly smashed its funding goal. The Yaw 2 is a compact mechanical stage that allows you to bolt on your favourite gaming chair and custom controllers to create a sophisticated moving VR experience. The ultra low latency haptic chair offers simple plug-and-play setup and 70 degrees of pitch, 40 degrees of roll and 360 degrees of yaw to take that VR experience to the next level.

US$99 | evercade.co.uk/vs

Evercade Vs

Get nostalgic with old friends.

Last year Evercade came out with a Nintendo Switch-like handheld portable console that allowed you to fire up a large catalogue of classic 90s games anywhere you wanted. The new Evercade Vs is a more traditional TV-based console, that means you can whip out classic arcade and console titles and play with up to four friends. Much like the originals, this blast from the past gaming system requires you to fork out for cartridges, although fortunately you can fit a few more onto the cartridges you've got in there.



$3,699 | lian-li.com

Lian Li DK-05F

The next evolution of streamlined PC-encasing desks.

Case maker Lian Li is back with another updated automated desk that you can build your next PC directly into. The DK-05F is a high tech desk with a central cavity that can accommodate two water cooled E-ATX PCs. The five included radiators should be enough to cool even the most demanding systems and an electrically switchable translucent or opaque glass tabletop that means you can hide or show off as much of your rig as you want.

US$329 | bose.com/en_us

Bose QuietComfort 35 II Gaming Headset

Can this headset adaptor from Bose do it all?

Bose has added a new microphone package to its excellent active noise cancelling QC 35 II headset that allows you to use it as both a gaming comms device and your work-friendly headphones. While the boom microphone is just an attachment that plugs into a USB PC adaptor, we haven't seen this module sold on its own. So for the time being you'll have to get it as a package. But it makes a lot of sense as a versatile all-in-one solution. ■

From $1,599 | microsoft.com/en-au

Microsoft Surface Laptop 4

The fourth iteration of the Surface Laptop is focusing on the finer details of laptop design, but is this pretty product still a competitive offering?

It doesn't feel that long ago that Microsoft was announcing its first Surface Laptops, but now more than a few years on we have the fourth iteration of this clamshell Surface range... and it's really starting to mature into a sophisticated and reasonably priced offering. What's most notable about the Surface Laptop 4 is that it's still one of the only Ultrabook ranges to offer various AMD and Intel based models side by side, clearly the strategy has been working for them since the Surface Pro 3 launched at the end of 2019.

In addition to processor choice, the Surface Laptop 4 devices offer much longer than average battery lifespans, vibrant 3 by 2 displays, a sophisticated chassis design and many sophisticated colours to choose from. Many of the upgrades might seem less dramatic with this year's Surface 4 update, but as we saw through the evolution of the Surface Pro range, as the updates get smaller, it usually means the devices are closer to exactly what you'd want in a laptop.

Size matters

In much the same way as it's always been, the main choice you'll make when buying the Surface Laptop 4 is the size device you want. You can opt for either a 13.5 inch display at a resolution of 2,256 by 1,504 or a 15-inch screen at a 2,496 by 1,664 pixel resolution. These PixelSense displays are designed to be as similar as possible with both featuring 201ppi resolution densities, a 3 by 2 aspect ratio and 10-point multi-touch glossy panel. They look vibrant and are more than adequate for general office use and media playback, but for anyone hoping to do professional colour work these screens only achieve partial sRGB colour reproduction and rely on Windows baked-in enhancements for HDR media. These screens are still ahead of many competitors in a number of ways, but if you're a designer or visual pro, you'll be better equipped with the DCI-P3 colours of a MacBook Air.

Harking back to a more traditional way of splitting laptop models, the screen you choose will affect how powerful the device can be in some ways. While you can get the 13.5-inch Surface Laptop 4 with your choice of an 11th Generation Intel Core i5 or a more powerful Core i7 processor, if you want an AMD processor you're limited to just the Ryzen 5 CPU. The 15-inch Surface Laptop 4 however can only be configured with the more powerful AMD Ryzen 7 or an Intel Core i7 processor.

The cost of business

AMD has been hamstrung a little in the 13.5-inch model options,

Best result
On test

	Microsoft Surface Laptop 4 13in	Microsoft Surface Laptop 3 13in	Microsoft Surface Laptop 4 15in	Microsoft Surface Laptop 3 15in
PCMark 10 - Overall (score)	4,144	4,049	4,852	3,975
HWBot x265 - 1080p (fps)	25.848	21.561	45.614	17.161
3DMark Time Spy (score)	1,505	861	1,422	899
Sid Meier's: Civilization VI - 1080p Low (fps)	53.60	Not tested	67.1	Not tested
Battery life - 1080p video playback (h:min)	08:23	04:48	09:22	05:56
Peak CPU temperature (°C)	[illegible]	100	95	78
CrystalDiskMark Read/Write (MB/s)	[illegible]	2,327	2,283	2,021.7

	Microsoft Surface Laptop 4 13in	Microsoft Surface Laptop 3 13in	Microsoft Surface Laptop 4 15in	Microsoft Surface Laptop 3 15in
RRP	$1,599-$3,849 ($1,999 this unit)	$1,699-$3,949 ($1,999 this unit)	2,199-3,999 ($2,699 this unit)	1999-4399 ($2,799 this unit)
CPU	Intel Core i5-1135G7	Intel Core i5-1035G7	AMD Ryzen 7 4980U	AMD Ryzen 5 3580U
Cores/threads	4/8	4/8	8/16	4/8
Frequency range	2.4-4.2GHz	1.2-3.7GHz	2-4.4GHz	2.1-3.7GHz
Memory	8GB	8GB	16GB	16GB
GPU	Intel Iris Xe Graphics	Intel Iris Plus Graphics	AMD Radeon RX Vega 8	AMD Radeon Vega Graphics 9
Hard drive	512GB Samsung PCIe SSD	256GB Toshiba PCIe SSD	512GB Hitachi PCIe SSD	256GB Hitachi PCIe SSD
OS	Windows 10 Home 64-bit	Windows 10 Home 64-bit	Windows 10 Home 64-bit	Windows 10Home 64-bit
Screen size	13.5-inch	13.5-inch	15-inch	15-inch
Screen type	PixelSense Touchscreen	PixelSense Touchscreen	PixelSense Touchscreen	PixelSense Touchscreen
Screen finish	Gloss	Gloss	Gloss	Gloss
Resolution	2256 x 1504 (201 PPI) resolution, 3:2	2256 x 1504 (201 PPI) resolution, 3:2	2496 x 1664 (201PPI) resolution, 3:2	2496 x 1664 (201PPI) resolution, 3:2
Wi-Fi type	WiFi 6/ 802.11ax	WiFi 5/ 802.11ac	WiFi 6/ 802.11ax	WiFi 5/ 802.11ac
Wi-Fi	Intel WiFi 6 AX201	Intel WiFi 6 AX201	Wi-Fi 6	Qualcomm Atheros QCA61x4A (Dual Band)
Battery type & capacity	45.8WH	45.8Wh	46Wh	47Wh
Weight	1.265kg	1.28kg	1.542kg	1.5kg
Dimensions (mm)	308 x 223 x 14.5	308 x 223 x 14.5	339.5 x 244 x 14.7	339.5 x 244 x 14.69

offered with a maximum storage of just 256GB. There is at least the option for either 8GB or 16GB of RAM that'll cost $1,599 or $1,899 respectively, but when your OS could take up half the storage space, it's not an ideal configuration for a premium Ultrabook.

The 13.5-inch Core i5 starts at $1,999 for models with 8GB of RAM and 512GB of storage and ranges up to a Core i7 configuration with 32GB of RAM and 1TB of storage for $3,849.

In the 15-inch AMD department you can get a Ryzen 7 processor with 256GB of storage and 8GB of RAM for $2,199 or a Ryzen 7 with 512GB of storage and either 8 or 16GB of RAM for $2,499 and $2,699 respectively.

The blue team's 15 inch options are a choice of a Core i7 processor with 16GB of RAM and 512GB of storage for $2,849 or an i7, 32GB RAM, 1TB storage model for $3,999.

On the whole, none of the 13-inch options are overly good value considering you can get plenty of similarly sized devices with 11th gen Core i7s, 16GB of RAM and 512GB of PCIe storage for around $2,000 and some of Apple's more powerful MacBook Pro and Air laptops for less.

That said, the $1,999 Surface Laptop 4 looks like the best balance of price and performance if you are going to go for the 13 incher. On the 15-inch side the Ryzen 7 with 16GB of RAM and a 512GB SSD is the sweet spot. Perhaps unsurprisingly, these are also the two units Microsoft sent us to test out for *APC*.

Performance

AMD's additional core count means that if you want more general computing performance they're going to be the best option, but traditionally Intel's Iris Xe Graphics processors have far outpaced AMD's integrated Radeon GPUs. Interestingly the AMD Radeon Vega 8 integrated GPU on the Surface Laptop 15 was able to keep pace with Intel's Iris Xe which makes it the undisputedly more powerful processor overall, even though they're generally priced more affordably here.

For general work tasks the Core i5 processor with 8GB or RAM is more than adequate and all the Surface Laptop 4 units offer similar light 1080p gaming capabilities, so everything up from here will just be gravy for most people.

If you are wanting to dabble in more demanding image processing or you need overhead to work while streaming video you'll probably want to opt for one of the more powerful 15-inch Surface Laptop 4 models, but you will then have to be willing to accept a 277g heavier 1.5kg overall weight that also comes with a bigger overall footprint.

Additional extras

With material finishes including everything from polished metal to a soft Alcantara material and Platinum, Ice Blue, Matte Black and Sandstone colourings you won't be disappointed by the look and feel of this exceptionally well designed device. The keyboards on both devices are spacious and really nice to type on with the 15 inches offering a little more key travel and the 13-inch units the soft Alcantra palm rests. The trackpad is one of the best we've felt and while we're a little disappointed it doesn't have a USB 3.2 port, it does at least have two USB 3.1 ports (1x Type-A, 1x Type-C) and an 3.5mm audio jack, in addition to the Surface Connect power port. All units get Wi-Fi 6 and a long lasting 46Wh battery.

Both devices offered solid general work battery lifespans in PCMark 10 benchmarks with the 15-inch AMD unit netting 10 hours and 11 minutes and the 13-inch Intel model lasting 14 hours. This'll translate to well over a day's work with the latter unit here being one of the longest lasting Ultrabooks we have on file for this benchmark.

JOEL BURGESS

The Surface Laptop 4 range is an uncompromising premium device for those happy to pay a little more for a well-rounded and fashionable laptop.

★★★★☆

$3,099 | asus.com/au

Asus ExpertBook B9400CE

Asus has added a new premium professional portable to its executive lineup, but it is a little hot headed to run the business?

Looking at the ExpertBook B9400CE from Asus, you'd be forgiven for thinking it was just another 11th Generation Intel Evo Ultrabook, but there are some things quite unique about this new premium portable laptop. For starters it ranges up to offerings with 32GB of RAM, and 2TB of PCIe storage for those willing to drop $3,099 on a lightweight professional laptop. If you're a pro photographer or videographer it might be worthwhile having a memory workspace that big, but you'd probably want a larger colour gamut screen for this kind of technical visual work (which is not available in the ExpertBook B9400 range unfortunately). While not professional colour work quality, the 14-inch 1080p display is at least 400 nits and IPS, so it looks good enough for general work applications and the 4mm bezels mean the screen pushes right to the edge of the envelope.

The clever trackpad and backlit number pad technology that Asus developed for earlier models returns again on this year's ExpertBook B9400, and the device's marketing boasts a lighter and more portable frame at 1.05kg with a 1.49cm thickness (even though last year's model was exactly the same thickness and weighed 995g). Still, no one is going to complain about having to carry this one around.

Asus went all out on military standard toughness tests to ensure this device was 'built for serious travel', despite the fact that the world really isn't doing much travel these days. The hinge test, port durability test, panel pressure test, keyboard durability test, shock test, drop test, vibration test, humidity test, altitude test and temperature tests that the ExpertBook passed means this magnesium-lithium alloy encased device isn't going to break anytime soon. There was some well targeted development in microphone noise cancellation that leverages AI to eliminate background noise in video conferencing and the speakers have been calibrated to sound loud and clear in a variety of conditions.

SPECS
Windows 10 Pro 64-bit; Intel Core i7-1165G7 CPU; 32GB RAM; Intel Iris Xe graphics; 2 x 1TB PCIe SSDs; 66Wh battery (11h24min 1080p movie playback); 32 x 23 x 1.49cm; 1.05kg.

The ExpertBook performed within five per cent of the average of all Evo laptop benchmarks we have on file in general work related tasks, but unfortunately it underperforms pretty badly in demanding encoding and gaming tasks: 19-24 per cent behind in HWbot x265 1080p media encoding and on average 30 percent worse than other Evo laptops in gaming and graphics benchmarks. So don't expect to play anything but the lightest games on this one. Considering we could pretty easily spike this CPU to 98-99 degrees, we're guessing that the ExpertBook is lacking in sufficient thermal management and the performance drop is due to throttling.

Battery life was above average, lasting well over a day at 11 hours and 43 minutes in home work tasks and 11 hours and 24 minutes in 1080p movie playback so there's plenty still to like in the ExpertBook B9400. Unfortunately you wouldn't willingly put your money into the top end models here and when you look at the value at the other end you'll see you can do a lot better elsewhere.
JOEL BURGESS

Best result
On test

	Asus ExpertBook 400CE	Evo average
PCMark 10 - Overall (score)	4,783	4,705.5
HWBOT x265 2.2 - 1080p (fps)	[illegible]	22.4
3DMark Time Spy (score)	[illegible]	2,607.1
Tom Clancy's The Division 2 - Low 1080p (fps)	[illegible]	33
Battery life - 1080p video playback (h:min)	11:24	07:51
Peak CPU temperature (°C)	100	97.5
CrystalDiskMark Read (MB/s)	3,495	3,157
CrystalDiskMark Write (MB/s)	[illegible]	2,519

A slightly expensive ultrabook marred by thermal and performance issues.
★★★☆☆

apc RECOMMENDS

$2,199 | acer.com

Acer Nitro 5

Acer's budget range of gaming laptops gets a new component injection.

We've loved the last couple of Nitro devices from Acer and it looks like the 2021 Nitro 5 is on track to deliver the same bang-for-buck value as its predecessors. Part of the reason these budget gaming rigs can afford to be such good value is that they harness the power of 10th generation Intel H processors, which were almost end-of-life when the first 2021 Nitro 5s hit shelves locally. Regardless of their age the i5-10300H or the i7-10750H are powerful mobile CPUs that'll give you enough under the hood to push through demanding workloads, creative projects and gaming.

In addition to the Intel arrangements, the Nitro 5 also has AMD models that range all the way up to a Ryzen 9 5900HX with an Nvidia RTX 3080 and 32GB of RAM for $3,999, which is pretty reasonable considering the power and the fact that it's currently widely available. There were AMD Ryzen 7, 16GB, RTX 3070 models made too, but good luck finding one in stock anywhere. We tested an i7, 16GB, RTX 3060 model that you can get for $2,199 from Harvey Norman, which definitely hits a sweet spot in terms of price and performance, but we'd opt for the similarly priced R7 AMD model from Wireless 1 if we had the choice. This rig sports a 15.6-inch 144Hz 1080p monitor for high paced online games and fast shooters, but it's actually quite bright and vibrant for a matte display. You'll get different screens for different models, so we can't really speak for the whole range and Acer has opted to sell different devices through different vendors so keep an eye on the specs table.

Main processing performance was where we'd expect from the 10th Gen i7 CPU which is fine for demanding work tasks, but is still between 20 and 35 percent behind the Ryzen 7 5800H. The Nvidia RTX 3060 performs nicely though, beating a 2060 (Max-Q) by about 25 per cent and trails behind the 3070 by about the same margin. You can expect to demolish most creative tasks and you'll get 60fps on many modern shooters at Ultra 1080p and over 100fps on anything less demanding.

SPECS
Windows 10 Home 64-bit; 15.6-inch 144Hz display @ 1920x1080p; Intel Core i7-10750H CPU; 16GB RAM; Nvidia GeForce RTX 3060 GPU; 512GB PCIe SSD; 55Wh battery (6h22min 1080p movie playback); 36.3 x 25.5 x 2.4cm; 2.3kg.

The Nitro 5 isn't the slimmest gaming laptop you can get, but even budget devices like this are under 2.5cm thick and weigh just 2.3kg, which makes them portable. The keyboard is nice to type on and the trackpad is quite usable. Someone definitely made an oversight with the rear powerport, which can be difficult to plug in, and the screen hinge doesn't offer consistent resistance so it can slam shut, but on the whole it's fine for a budget rig.

Battery life was pretty good for a gaming laptop lasting four hours and 26 minutes in PCMark 10 battery benchmarks and 6 hours and 22 minutes in 1080p movie playback. It's still a long way off the five hours and 59 minutes and eight hours an 18 minutes respective lifespans you get on an Asus TUF gaming running a Ryzen 7 5800H and a RTX 3070, but laptop vendors seem to still be keeping red CPU configuration runs to a minimum, so we can't imagine you'll actually be able to buy an AMD laptop anytime soon.

JOEL BURGESS

Best result
On test

	Acer Nitro 5	Asus TUF Gaming A15
PCMark 10 - Overall (score)	5,200	6,823
Max CPU Temperature (C)	95	91
1080p movie playback (HH:MM)	[illegible]	08:18
HWBot x265 - 1080p (Ave fps)	[illegible]	[illegible]
3DMark Time Spy (score)	[illegible]	[illegible]
The Division 2 - 1080p Ultra (fps Av.)	[illegible]	95
CrystalDiskMark Read (MB/s)	[illegible]	[illegible]
CrystalDiskMark Write (MB/s)	[illegible]	2,976

If you can't get an AMD model the i7 Acer Nitro 5 is a good-value alternative 1080p gaming laptop.
★★★★☆

apc RECOMMENDS

$200 | www.qnap.com

QNAP QMiro-201W

A fast, tri-band mesh Wi-Fi router with business focused work from home features.

Patchy Wi-Fi signal strength is a true horror, but to help upgrade your network QNAP has released the new QMiro-201W tri-band mesh router. It has some business-focused features, but is also well-suited to normal home use, and comes in a unique baby blue.

The QMiro-201W AC2200 spec, which means dual band 802.11ac (2.4 and 5GHz) plus two more 5GHz bands across four internal antennas. The router itself has two GbE ports – WAN and LAN, plus a USB 3.2 connection, and Bluetooth. Each router is rated to cover 195 square metres, which translates into enough for a one or two bedroom apartment. The 201W is mesh capable, which means adding in extra coverage is simple as buying another router – no cables needed. Being Tri-Band, the units can use a high speed 5GHz connection to talk to each other, without compromising bandwidth to your other network devices. The router has inbuilt features that allow parental and quality of service controls, VPN creation, Wi-Fi scheduling, and even USB FTP creation.

Uniquely for such a device, the QMiro-201W can be used with the fairly sophisticated QNAP QuWAN (SD-WAN) solution. In a nutshell, the QuWAN software makes it very easy for a business to connect remote workers securely and reliably into their network. It also brings the mesh architecture to the WAN, creating a much more fault tolerant network. An in-depth QuWAN dive is beyond the scope of this review, but suffice to say it's a new and interesting feature that will appeal to businesses with people working from home.

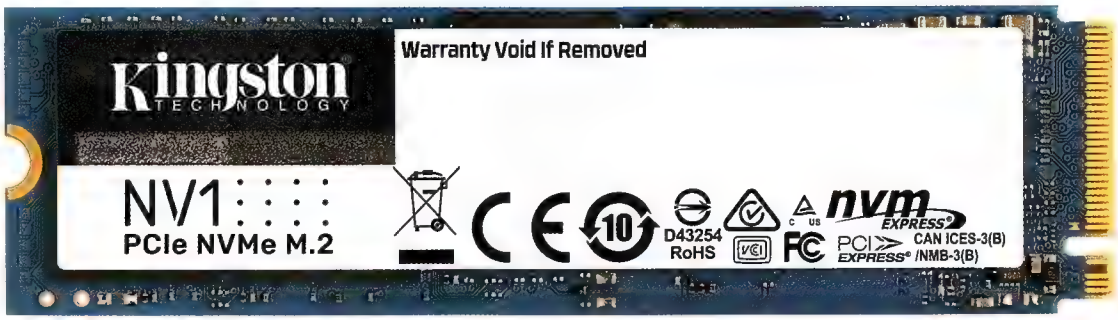
Setup was a little more complicated than we would have liked, and after a number of frustrations with the app, we resorted to the web interface, which worked without any issues. Getting the router up and running requires a QNAP ID, and expect firmware updates to take a little while, but after that configuration was straightforward. Adding a second QMiro-201W for mesh networking was fast and easy, and the routers maintained excellent speed and seamless handovers between nodes. During normal operation we had no issues using the app to manage the network. The colour change status light (which can be turned off) and alert beeps were also a nice touch.

Performance and coverage will depend on exactly what devices you connect with, and your environment, but generally we found the claim that a single QMiro-201W can cover the area of a 2 bedroom apartment to be true. Up close we could happily manage almost 300 Mbps, which dropped off to around half that two rooms over. Thanks to the extra 5GHz link, the mesh backhaul connection happily maintains near full speed performance back to the main router even when multiple rooms away.

The $200 price tag for the QNAP router is very competitive with other Tri-Band WiFi routers, but it might be overkill if you don't need the performance, or extra functionality. At this stage the QMiro-201W isn't available in multipacks, which can make it much more expensive than the competition for covering larger houses. Still, it's a solid choice, and potentially must have for certain businesses that can utilise QuWAN.
LINDSAY HANDMER

SPECS
WiFi: 802.11a/b/g/n/ac, AC2200; 4x Internal Antennas; 2x 1GbE Ethernet; 1x USB 3.2; Qualcomm Cortex A7 CPU; RAM: 512MB DDR3; Power: 24W; Dimensions: 68 x100 x 176mm.

While there's no multi packs available to save a little money, the QNAP QMiro-201W is nonetheless an excellent mesh Wi-Fi router that will appeal to both home and business users.
★★★★☆



$139 | www.kingston.com

Kingston NV1 1TB M.2 NVMe SSD

SATA killer?

It seems like just yesterday we were talking about how SSDs have replaced hard drives in all but the most affordable systems and laptops. Is it time for a new conversation? Is SATA now useful for secondary storage only? NVMe drives continue to reduce in price, especially now that PCIe 4.0 drives are widely available leaving PCIe 3.0 drives as affordable options. And there are very few NVMe drives that are more affordable than the Kingston NV1.

The Kingston NV1 1TB is an NVMe M.2 2280 (80mm length) drive that makes use of a PCIe 3.0 x4 interface. This is the part of the review that we'd go over the flash or controller, however, unlike most manufacturers that disclose fairly detailed specifications, Kingston doesn't for the NV1. We believe this is so that Kingston is free to switch out the controller and flash in the future. In a cut-throat market where every cent matters, this gives Kingston the freedom to switch to cheaper and/or more plentiful components as the market dictates. These midlife changes have caught out other manufacturers in the past. What you really need to know is the sequential speed rating, which is 2,100/1,700 MB/s sequential read and write. The 1TB model we have for review has a 240 TBW endurance rating. Combine this low endurance rating with a three-year warranty, and it's clear we're looking at a budget drive.

Sequential read and write performance is always the headline on the packaging, but it's important to remember that it's the random performance and IOPS that make an SSD feel fast. Where a good SATA drive returns a result of around 130 seconds, the NV1 does it in 47.

As SSDs become more or less commodity items, pricing is absolutely critical. At the time of writing the 1TB Kingston NV1 can be found for as little as $130. That's on par with the cheapest 1TB SATA drives! That alone would lead us to rate the NV1 very highly, however the Crucial P1 is available for similar prices, and it comes with a five-year warranty vs the three of the NV1.

It's getting hard to recommend SATA drives for any purpose other than as secondary storage. The Kingston NV1 is a solid upgrade for a user with a low-capacity NVMe drive, like you'd find on a budget laptop. It won't break any speed records but at these prices we don't expect it to. Having said that, Kingston needs to be a little cheaper if we are to unequivocally recommend it. 10 or 20 bucks more gets a you a faster drive with a longer warranty and better endurance. But, if you're looking for some extra capacity on the cheap and care about little else, the Kingston will do the job.

CHRIS SZEWCZYK

SPECS
Kingston NV1 1TB NVMe M.2 SSD; PCIe 3.0 x4 interface; 2100MB/s sustained read, 1700MB/s sustained write; 240 TBW endurance; three year warranty.

Best result
On test

	Kingston NV1 1TB	Samsung 860 Evo
Crystal Disk Mark - Sequential Read (MB/s)	2,084	548
Crystal Disk Mark - Sequential Write (MB/s)	1,748	495
Anvil Storage Utilities - 4K Random Read MB/s Queue Depth 1	50.03	40.29
Anvil Storage Utilities - 4K Random Read MB/s Queue Depth 4	184.11	149.01
Anvil Storage Utilities - 4K Random Write MB/s Queue Depth 1	200.20	94.64
Anvil Storage Utilities - 4K Random Write MB/s Queue Depth 4	682.15	179.18
Anvil Storage Utilities - 4K Random Read IOPS Queue Depth 1	13,010	10,024
Anvil Storage Utilities - 4K Random Read IOPSQueue Depth 4	48,405	38,763
Anvil Storage Utilities - 4K Random Write IOPS Queue Depth 1	52,372	24,847
Anvil Storage Utilities - 4K Random Write IOPS Queue Depth 4	174,631	46,544

The Kingston NV1 will add welcome capacity to a budget system or laptop but otherwise it doesn't stand out.

★★★⯪☆

apc HOT PRODUCT

$3,599 | www.asus.com/au

Asus ROG Swift PG32UQX

A big expensive monitor from Asus that promises the world. Can it deliver?

We recently mentioned that monitors are one of the few technology categories that isn't commoditised: most models specialise or compromise in various areas of performance and value. So, we love it when a monster like Asus' PG32UQX comes along. There's no compromising here. It offers Display Stream Compression (DSC), HDR 1,400, a 144Hz refresh rate, 1,152-zone mini-LED dynamic rear lighting and G-sync Ultimate – all on a matte, 32-inch, IPS screen with a 3,840 x 2,160 resolution – all the things that genuinely make the best content look awesome.

We started at the top, which for this reviewer means *Far Cry 5* in HDR. On a good monitor this game's visuals are phenomenal, with smooth motion, back-lit objects genuinely glowing, light flooding out of the screen and bright objects practically popping out of dark environments. The PG32UQX's performance told us it was a very good monitor.

We moved onto *The Darkest Hour,* which is literally dark and full of shadows that are punctuated by a few bright lights. We were rewarded with exceptional detail in shadowy areas, smooth monochromatic gradients and sharp relief elsewhere. We stepped things up further and ran LG's OLED TV display test reels to gauge colour vibrancy on true-black backgrounds and were once again impressed: colours burst off the screen and were surrounded by largely true-black backgrounds. While there was some light bleeding from the rear-mounted mini LEDs it was minimal and contrived to generate the best contrast performance we've seen from any LCD screen. Quite simply, this monitor displays all high-quality content exceptionally well.

Gone are the days where setting up HDR screens involved bespoke drivers, Windows gymnastics, hope, and luck. Nowadays, you just slide a switch on Windows' display settings. When we turned it off, colours became governed by the display's pre-sets and adjustments. We found sRGB mode made office work particularly comfortable to perform albeit at the expense of colour vibrancy.

The monitor looks good on its own too. It might not have the thinnest bezel but the stylised contouring, graphical flourishes and down-firing (customisable) projected logo lets people know this is special even when turned off. Just note that the three-pronged base does not have a small footprint, but it does provide stability to the substantial screen. Adjustments include 70mm height, +20o to -5o tilt and +/- 20o swivel.

The OSD is intuitively accessed via a spinning switch and two buttons at the base and adds some nifty gaming features. These include on-screen crosshairs for FPS shooters and a black booster setting which ruins contrast but reveals people hiding in shadows. Below the screen, a mini 'LiveDash' OLED display shows bespoke logos or system information while Aura Sync technology matches RGB lighting configurations with compatible peripherals. Other interesting features include a top-mounted tripod socket and USB port for streamers.

Few people wouldn't want this monitor, but few could afford it at $3,599. However, its ability to make top content so incredibly immersive means the PG32UQX is still good value and a worthwhile investment.

NICK ROSS

SPECS
32-inch, matte, 3,840 x 2,160, flat-screen, 10-bit, 144Hz, IPS LCD. 4ms G2G response time. 500 nit brightness (SDR), 1000:1 contrast. DSC. 98% DCI-P3, 160% sRGB, gamut Delta E<2 (factory calibrated). HDR10, VESA DisplayHDR 1,400. G-Sync Ultimate. DisplayPort 1.4, 3 x HDMI 2.0, 2 x USB 3.1, 1 x USB 2.0, 3.5mm audio jack. Tilt -5o/+20o, -20o/+20o swivel, rotate or height adjustment. IR Remote. 504-574 x 727 x 306 mm, 10.9KG.

Big, expensive and worth every cent. Glorious.
★★★★★

apc RECOMMENDS

$649 | au.aoc.com

AOC U34G3X gaming monitor

Ultrawide and ultra capable without ultra pricing.

Do you need an ultrawide gaming monitor? It's certainly the first question to answer for yourself before considering the AOC U34G3X – a 34-inch beast of a screen with some pretty impressive specs to match. Would your day-to-day use and gaming benefit from a 21:9 aspect ratio rather than 16:9? Do your games or consoles even support the format? If so, read on.

Aesthetically, this AOC monitor treads a comfortable line between understated elegance and lavish gaming flair. On the front, limited branding and text along with thin bezels make sure the display itself is very much the centre of attention. The monitor's stand holds the product's only real design flourish, with some red trim accenting a large cable management hole in the centre of the vertical support and some particularly long feet drawing some of the eye's attention. This latter component is likely to accommodate for the impressive 23° of bi-directional swivel the ultrawide monitor is capable of – when you swing something nearing a metre in width, you want to make sure it's supported.

Also of note in the adjustability department: the display can move a full 13cm up or down, with this and all other tweaks being made effortlessly but not feeling flimsy or unsecured.

One area where the flimsiness is notable, however, is in the front panel buttons. To be fair, we've rarely encountered a monitor that does this well, but operating the intricate menu systems on board the AOC U34G3X is tedious enough already without having to also interact with wobbly buttons that don't always register a press.

Where the U34G3X truly shines is when you're playing games that not only support the ultrawide format, but truly benefit from it. While in FPS titles you'll receive some extra peripheral vision, in strategy titles, like *Civilization V*, it means being able to see a much larger area of the map at once, handily increasing your ability to strategise while also reducing the need to scroll around. This panel also features a 1ms response time for almost zero-lag gaming, while FreeSync and a 144Hz refresh rate combine to deliver buttery-smooth frame rates.

The display's 300 nits of brightness is relatively low compared to others in the market – but for better you'll be paying more. It's still plenty enough to still show a clear image with some ambient room lighting, and the HDR10 support offers better contrast (with three variable settings for picture, movie or game). This AOC display's colour accuracy makes it more than good enough for gaming and watching movies, and unless you're editing a major cinematic release, you'll find it good for most other creative work as well. There's a wealth of settings to modify your visual experience including a full menu dedicated to gaming settings, but you'll have to navigate these with the aforementioned flaky buttons.

When looking at the full package – with the massive size, resolution, refresh rate and more – there's little that competes with this AOC monitor at its $649 price point. So if your answer to this review's opening questions are 'yes', then the AOC U34G3X is your friend.

HARRY DOMANSKI

SPECS
34-inch, matte, 3440x1440, 1ms response time, flat-screen, 144Hz LCD with IPS panel, 300 nit brightness, 1000:1 contrast, 2x DisplayPort 1.4, 2x HDMI 2.0, 4x USB 3.2 Gen1, 3.5mm audio jack, tilt -5°/+23°, swivel -23°/+23°, 13cm height adjustment,

If you truly need ultrawide gaming, then this AOC screen offers a whole lot of bang for the buck.
★★★★☆

"The design looks incredible, the tempered glass really adds a fantastic accenting glamour to the whole thing, and the interior setup and layout are easy to move around in and extremely versatile, enabling you to install all manner of hardware in any way you can imagine."

apc HOT PRODUCT

$199 | lian-li.com

Lian Li PC-O11-Dynamic

Bulky brilliance

We've coveted and recommended this case for some time, but it has a bit of a reputation among system builders as being, well, something of a cliche. Why? Mostly because it's almost too good. In fact, it's so good, and has received so many awards over the last couple of years, and been praised so much around the tech community for its incredible versatility, top-quality materials, and easy building experience, that it's almost become a meme.

Indeed, it's the go-to chassis for liquid coolers, for sure, and there's good reason for that. Cooling support for the PC-O11is exemplary. As standard, it can support up to three 360mm radiators in the front of the chassis alone, and we're not talking skinny boys here, but big chunky rads up to a maximum of 90mm. Then there's the numerous distribution plates available from third parties, pump mounting support, and maximum compatibility for up to nine 120mm fans in a more ordinary configuration, or 18 120mm fans if you run push-pull on everything with that triple-rad setup we mentioned earlier. It's nuts.

And it's not just for liquid-coolers. From advanced air-cooling solutions to liquid-cooled behemoths to RGB giants, dual-PSU systems, and beyond, if you can think of it, someone's probably already got a detailed build log of it somewhere online, and another company's using it to advertise their own products elsewhere, too. It's such a popular case.

Its strengths are numerous. The design looks incredible, the tempered glass really adds a fantastic accenting glamour to the whole thing, and the interior setup and layout are easy to move around in and extremely versatile, enabling you to install all manner of hardware in any way you can imagine. You can install a 360mm AIO in three separate locations, you could have vertical GPUs if you want, you can do all that with enough fans to float a hovercraft, and then there's the rear of the case, littered with even more options. It can support dual power supplies. It has a dedicated 3.5-inch harddrive caddy. There's vast amounts of room for cable management, plus smart cable grommeting all around, too. It's crazy how much is included. It's perhaps the best dual-chamber chassis we've ever seen. And the fact it's available at $199 makes it one of the best value cases you can get at this price point, too. Its only weaknesses lie in its size and perhaps its lack of expandable storage options.

There's a good reason why this case has turned into such a meme, and even though system-builders and enthusiasts like ourselves like to rib on it for being such a common case, this thing does its job well – really well.

And you can't hate it for that. If you're after a chassis with an air of premium around it, plus a ton of versatility, and you don't mind the hefty dimensions this beast provides, the Lian Li PC-O11-Dynamic is perhaps the ultimate pick.

ZAC STOREY

SPECS
E-ATX, ATX, M-ATX, ITX; 4x 2.5-inch, 2x 3.5-inch drives; max radiator: 360mm roof, 360mm side, 360mm bottom; fan support: 3x 120mm/2x 140mm roof, 3x 120mm side, 3x 120mm bottom.

Epic design, easy to build in, brilliant versatility, incredible cooling potential, strong pricing, nice colour variants.

★★★★½

apc RECOMMENDS

$250 | www.qnap.com

QNAP TS-130

A simple home NAS with the performance to handle more than just backups.

In a sea of small NAS, what makes the QNAP TS-130 stand out? Aside from the self described "elegant" baby blue colour, the TS-130 is a memory-focused NAS with the ability to stream 4K video. The rest of the spec is pretty standard, – not a bad thing at all, since the biggest drawcard is actually the software available.

But first the hardware. The $250 TS-130 has a single 3.5in SATA drive bay, one Gigabit Ethernet port plus dual USB around the back. It's powered by a Realtek RTD1295 SOC that buzzes along at 1.4GHz, backed up by 1GB of DDR4 RAM. The RTD1295 is common in things like Android media players, and consists of an ARM Cortex A53 CPU, a Mali-T820 GPU, and supports hardware decoding of 4K H.265 files at 60fps. It doesn't do hardware transcoding, but still makes for a pretty solid starter Plex server. One USB port is 3.2 spec and accepts external HDDs, QNAP expand units, or even a 5GbE adapter. The other can handle USB devices such as printers, wireless network adaptors.

Opening the TS-130 involves removing one screw, taking off the cover and slotting in your drive. You could use a 2.5in (with an adaptor plate) but there's no real point. HDD installed, the NAS is fast and simple to get up and running, and QManager makes it easy to access and manage from a mobile device. There's loads of apps available, from backups, photo and video management, to productivity and surveillance. QNAPcloud simplifies data sharing across devices, and to friends and family. You can even integrate your existing cloud storage in as part of the NAS volumes.

In testing, the QNAP has the chops to saturate the ethernet connection at 111 MB/s up and 112 MB/s down. Turn on encryption (as everyone should) and you won't see a noticeable drop in performance, which is great. The (not expandable) 1GB of RAM is decent, but you can slow things down if running many apps at once, or trying to serve up media files to an excess of devices.

"In testing, the QNAP has the chops to saturate the ethernet connection at 111 MB/s up and 112 MB/s down."

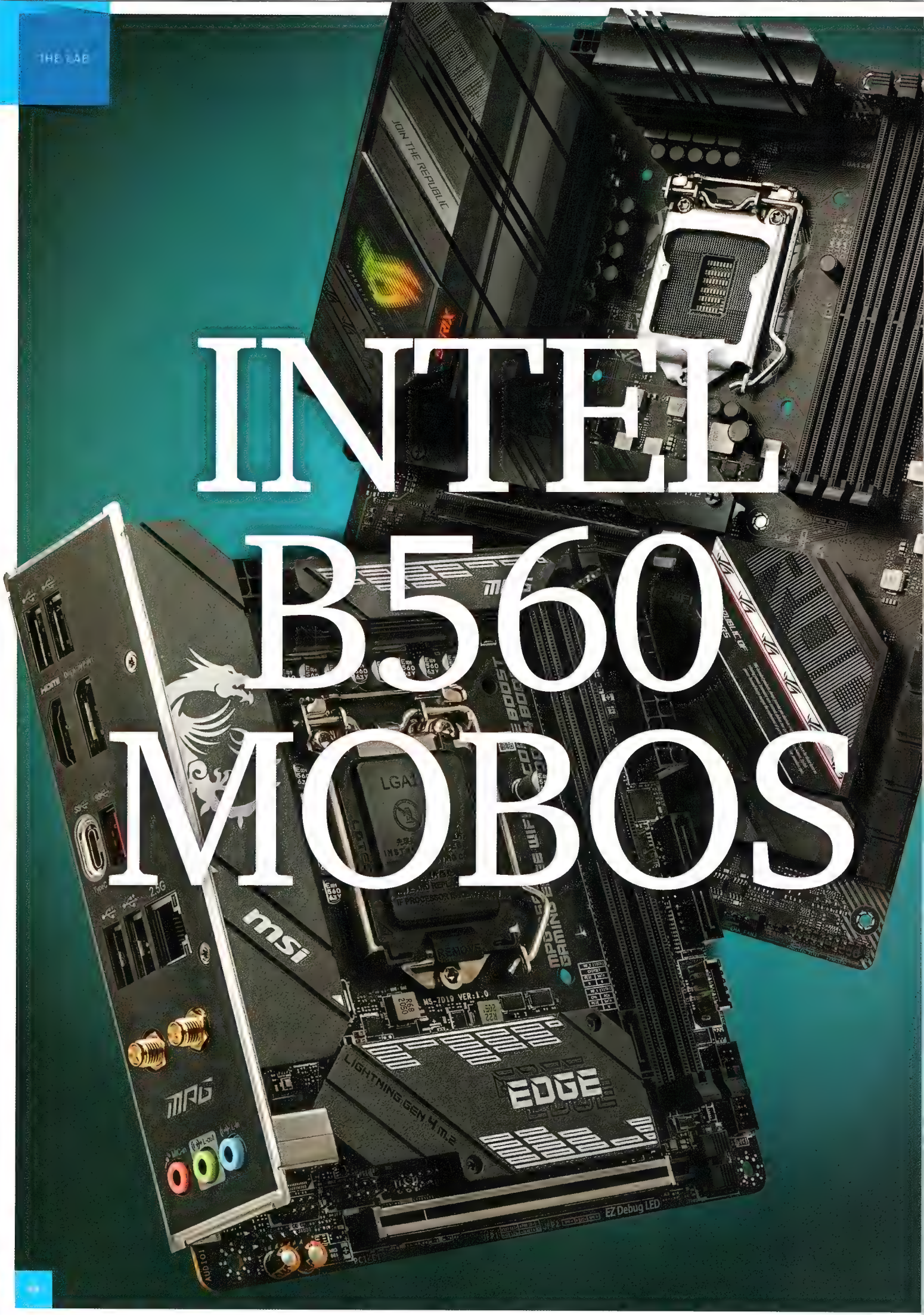
SPECS
CPU: Realtek 1.4GHz Quad Core; RAM: 1GB DDR4; Drive Bay: 1x 3.5in SATA; 1x Gigabit Ethernet; 1x USB 2.0, 1x USB 3.2; 187 x66 x158 mm.

We averaged around 7 watts (5W to 12W) during normal use, and the cooling fan stays relatively quiet under heavy load. We had no issues doing backups / snapshots and restores, and streaming via Plex was as good as on any other NAS we've tested. The productivity apps mostly focus on file storage and sharing, and integrating Microsoft Office rather than offering their own solution. QVR Elite is a solid surveillance option, and comes with two camera licences for free. There's also loads of other apps available in the QNAP app centre. Security is decent, with options for an automatic security advisor, IP blocking, 2-step verification and notifications.

The TS-130s biggest competition comes from it's sibling, the TS-230, which features the same CPU, with 2GB of RAM, dual drive bays, and an extra USB port on the front, for a modest $50 price increase.
LINDSAY HANDMER

An above average CPU and RAM combo, solid features and affordable price make the QNAP TS-130 (and the two bay TS230) worth considering.
★★★★☆

INTEL B560 MOBOS



Don't ignore B series motherboards anymore. Chris Szewczyk explains why.

B560 motherboards are interesting. You read that right! With exceptions, previous generation B series motherboards were mostly underwhelming unless you were specifically building a budget system. They tended to have weak power delivery, lacked connectivity, and they were stuck with limited memory speeds. While you'd still expect entry-level B560 boards to remain on the basic side, the premium level B560 boards can be superior to similarly priced Z590 boards. They still lack CPU overclocking, but with limited overclocking headroom on K-series 11th generation CPUs anyway, OC support doesn't weigh very highly this generation. We've got a couple of premium B560 boards in the labs for a look. Should you consider one over a similarly priced Z590 board?

What's new?

PCIe 4.0 makes its debut with 11th Gen CPUs, and it's supported on B560 motherboards too. You get a full speed PCIe 4.0 x16 slot to suit modern GPUs and a PCIe 4.0 x4 M.2 slot. In addition, you get another 12 PCIe 3.0 lanes from the chipset. Four of these will most likely be taken by a second M.2 slot leaving eight lanes for some combination of a third slot and/or PCIe slots or additional controllers. While a single GPU system with a fast SSD and a couple of SATA drives will perform perfectly well, if you're planning to use two or more M.2 drives plus expansion cards, you'll probably run out of lanes, and in that case you're better off with a Z590 board.

B560 motherboards finally introduce memory overclocking support. This fixes our biggest gripe with B460. Now that DDR4 is a well and truly mature technology, with DDR4-3200 and now DDR4-3600 costing little more than a 2400 or 2666MHz kit, it makes sense to allow support for faster speeds. No longer are you losing performance because of some arbitrary Intel restriction. AMD's B Series chipset paved the way, and now Intel has caught up.

OC limitations

Some will say that Intel should allow CPU overclocking with the B560 chipset like AMD does with its B550 boards. It's important to remember that AMD's processors don't consume anywhere near as much power. The cheapest 11th Gen K CPU, the 11600K can pull over 200W under a heavy AVX-512 load. Even a 16-core Ryzen 5950X doesn't consume that much. AVX-512 isn't widely used in consumer software but it is there, and the boards have to be able to run under the worst-case scenarios. Our greatest criticism of 11th Generation CPUs is their high power consumption and to cope with this, B560 boards feature improved VRM designs compared to their predecessors. Don't expect too much from a cheap board, but almost anything in the $200+ range will feature a VRM that can run an 11900K, and though you can't overclock, you're not missing out on much. Rocket Lake processors are already pushed to their limits.

While we're not fans of arbitrary restrictions, we can understand Intel not wanting to allow OC on entry level boards that would probably go up in smoke when presented with an overclocked AVX-512 load. If Intel had an 11th Gen quad-core K CPU, that would be fun, but that's a discussion for another day.

Elsewhere in this issue you'll find our Core i5-11400F review. It's our new favorite budget CPU and it offers awesome performance at its price point. It's a natural match for a B560 motherboard. If you ignore the horrendous GPU market, you could build a really powerful system for not much money. Add a sub-$250 i5-11400F, a $150 motherboard, and $150 for 2x8GB of DDR4-3600 and you have the base of a surprisingly powerful system, albeit one that still consumes too much power for our liking.

Advanced I/O

Connectivity support has really improved, with B560 boards often matching similarly priced Z590 boards. USB 3.2 Gen 2 can be found on mid-range B560 boards, and USB Gen 2 2x2 (20Gbps) even appears on the higher end boards. 2.5G Ethernet controllers are increasingly common, which is a godsend for anyone used to transferring files over a NAS or making frequent backups. Wi-Fi 6 can also be found and a handful of boards even offer Wi-Fi 6E. Wi-Fi will continue to be rare on budget boards, though some include the older Wi-Fi 5 (802.11ac) standard. Wi-Fi 6 hands down beats out Wi-Fi 5 with OFDMA really benefitting a multi-user, multi-device household.

B560 boards offer some pretty awesome value too. A cheap board remains a cheap board but once you move above $200 a casual user will hardly care that they're using a B series board. Once you move above the $300 mark, the handful of boards in this range really do look like premium offerings.

For our testing we used the flagship i9-11900K. The 11900K is admittedly an unlikely pairing with anything other than a mid or high-end Z590 board, but we're covering high end B560 boards, and if they struggle with a stock 11900K then they are poor boards, it's as simple as that. It also means that if they can handle an 11900K, then they can handle anything you care to throw at them. You'll even be able to relax the power limits on the locked CPUs to allow longer turbo boost clocking.

When adding everything together, a decent B560 board can run a high performing Rocket Lake processor, a PCIe 4.0 graphics card and SSD, 64GB of DDR4-4000+, many TB of SATA storage, plus WiFi 6, 2.5G Ethernet and USB 3.2 Gen 2. All together that sounds like the base of a very high-performance system. What's missing? Overclocking? 98 percent of the market can live without that. B series motherboards just got a lot more interesting.

For testing we've got two B560 motherboards on hand. They are the Mini ITX MSI MPG B560i Gaming Edge and the ATX Asus ROG Strix B560-F Gaming Wi-Fi. Though neither can be described as truly budget boards, they do offer a lot for the money and are great examples of what a premium Intel B series board can offer.

$309 | www.asus.com

Asus ROG Strix B560-F Gaming Wi-Fi

A whole lot of board for the money.

The Asus ROG Strix B560-F Gaming Wi-Fi is one of the more expensive B560 boards and it gives Z590 boards around the same price a serious run for their money. It looks every bit a premium board. The little RGB ROG logo adjacent to the I/O adds a touch of class to the subtle mostly black aesthetic.

It features 3x M.2 slots, where the topmost one one connected to the CPU with a PCIe 4.0 connection. The others are PCIe 3.0. All slots come with metal heatsinks. Its one of the few B560 boards to come with heatsinks for all three slots. Notably they come with Asus' Q-Latch mechanism. No more fiddling with minuscule screws! You also get six SATA ports. Also worthy of note is the inclusion of Realtek S1220A audio. This is more common on high-end boards, with most B560 boards making use of cheaper codecs. It's one of many features that belie the fact that we're looking at a B560 board.

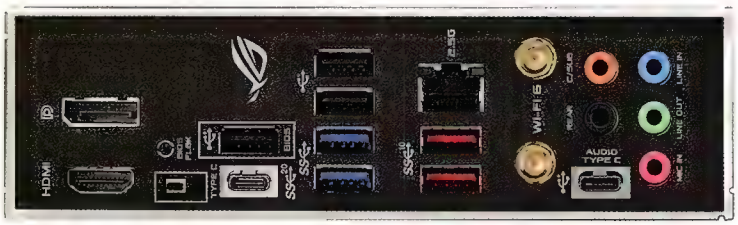
The Strix B560-F includes an 8+2-phase VRM with 50a stages. An 8-pin EPS connector provides the juice. That's perfectly adequate for any 11th generation CPU, especially since OC isn't allowed on B560 boards. The heatsinks are aren't huge but they're a massive improvement over some of the garbage heatsinks you'll find on cheap boards. Under a full AVX load with an 11900K, VRM returned a temperature of 63 degrees, a very good result.

The rear I/O features a great array of ports. We're pleased to see a Type-C USB 3.2 Gen 2x2 port along with two Gen 2 ports, two Gen 1 ports and two 2.0 ports. That should take care of the needs of most users. Networking duties are provided by Intel 2.5G and Wi-Fi 6 controllers. Wi-Fi 6E would have been a cherry on top and the MSI B560i includes it but 6E still mostly confined to high end boards for now. DP and HDMI ports will be welcome for users looking to make use of 11th Gen Xe onboard graphics. Also note the omission of the common S/PDIF port in favor of a USB Type-C port. This adds some flexibility by allowing easy compatibility with Type-C headphones or an external DAC. S/PDIF or USB? That's a question that deserves its own article.

SPECS
LGA 1200 socket; 3x M.2; 6x SATA; 1x USB 3.2 Gen2x2, 2x USB 3.2 Gen 2, 5x USB 3.2 Gen 1, 8x USB 2.0; 1x HDMI 2.0, 1x DP 1.4; Intel Wi-Fi 6; I225V 2.5G LAN; Realtek S1220 7.1 Channel HD Audio; ATX Form Factor.

The Strix B560-F performed as expected in our benchmark suite, particularly under heavy multi-threaded loads compared to the little MSI. It also did ok in the gaming tests. Not that you can get better performance if you relax the power limits – if you're running a low end CPU you'll be able to extract more. The board certainly has the VRM headroom to do it.

The Asus B560-F is an excellent board that's packed with features. Our only gripe, if it can be called that, is it may be too much board for its own good. At $300+ its well into Z590 territory, but if you're not overclocking or running a load of drives and expansion cards, do you need Z590? If you look at a board like Asus' own Z590 TUF, it's a good $50 more without really adding a lot more. At $309 we feel the Asus is priced just right, and it resets expectation of what to expect from a premium B series board.



A healthy selection of I/O options are present, including a pair of Type C ports.

The Asus Strix B560-F is a feature packed and refined board that blows any 'B means cheap' perception out of the water.
★★★★½

$309 | www.msi.com

MSI MPG B560i Gaming Edge Wi-Fi

Wi-Fi 6E isn't restricted to high end boards.

The MSI MPG B560i Gaming Edge Wi-Fi is one of very few B560 Mini-ITX offerings. It incorporates a bit of a retro spectrum analyser aesthetic. We thought the look was a bit garish on the MSI Z590 Gaming Carbon, but here it looks really nice. These days you can pack a lot of tech onto an ITX board, with less need for auxiliary controllers or expansion cards. Yet for some reason ITX hasn't really caught on outside of its dedicated base. There's nothing really stopping you from running an 11900K with an RTX 3090 and 64GB of RAM on this little board.

The MSI B560i Gaming Edge features a basic VRM. This is partly due to space constraints. The 6+2+1 phase design is powered by a single 8-pin power connector. During our testing with a stock 11900K, we saw a VRM temperature reading of 73c, which is the highest we've seen out of the 500 series motherboards we've tested to date. Though it's still within spec, it illustrates that you need decent airflow to keep the VRM cool with Rocket Lake processors. Don't forget that more worldly 11th Gen processors will not face any VRM temperature issues.

You get 4x SATA and 2x M.2 slots. The front one is the PCIe 4.0 slot, which is cooled by a heatsink. The rear slot on the back of the PCB doesn't have a heatsink, and due to typically poor airflow in this area, do keep an eye on your drive temperatures. This configuration reveals a major weakness of the ITX form factor in the age of M.2 slots. There just isn't enough PCB space to accommodate multiple drives.

The rear I/O is weak point of the board. You get Type-A and Type-C USB 3.2 Gen 2 ports and four USB 2.0 ports. That's it. It's not enough. Other ports include HDMI 2.0b and DP 1.4. The budget ALC897 links to three analogue audio ports, though there's no S/PDIF. If the selection of USB ports is poor, the same can't be said of the board's networking with Realtek 2.5G Ethernet and Wi-Fi 6E, which is very rare for B560.

Performance-wise the little MSI performed as we'd expected with our 11900K. It proved to be very competitive in the gaming tests but it tends to trail ever so slightly in multithreaded benchmarks. We believe that power management is the reason for performance fluctuations rather than any design weakness.

MSI B560i Gaming Edge sits in a bit of a difficult position. Fans of ITX have only a handful of options and if you're looking to build a small form factor system with good networking then you'll be happy. The problem is the ATX boards at this price feature better power delivery and bigger heatsinks. They offer more SATA and M.2 ports and more USB ports. At this price the Asus B560-F is a tough competitor as is MSI's own very highly regarded B560 Tomahawk. If you don't need a ton of expansion capability then you'll be fine but we feel that the board doesn't offer enough at this price. If you are looking to go down the ITX path it's certainly a solid choice, but this little MSI leaves us wanting more.

SPECS
LGA 1200 socket; 2x M.2; 4x SATA; 2x USB 3.2 Gen 2, up to 3x USB 3.2 Gen 1, up to 6x USB 2.0, 1x HDMI 2.0, 1x DP 1.4; Intel Wi-Fi 6E; Realtek 8215B 2.5G LAN; Realtek ALC897 7.1 Channel HD Audio; Mini-ITX Form Factor.

While the MSI MPG B560i has scant few USB I/O options, it does include the newest Wi-Fi 6E standard.

If you must go ITX and require Wi-Fi 6E you'll be happy but at this price it can't match superior ATX offerings.
★★★⯪☆

Intel B560 Motherboard benchmark results

Best result
On test

	X264 v5.0 Video Encoding	Cinebench 20		Blender 2.79 BMW Render	7Zip	POV-Ray 3.7.1	Handbrake Video Encoding
	Pass 2 Avg FPS	Multi thread Score	Single thread Score	Time (seconds) Lower is better	Million Instruction per second	Ray Tracing - Pixels Per Second	4K 10-Bit HEVC to 1080p FPS
Asus TUF Gaming Z590-Plus Wifi	44.57	5,726	639	206.3	56,747	6,094	71.6
MSI B560i Gaming Edge Wifi	44.05	5,771	626	211.1	57,089	6,004	71.7
Asrock Z590 PG Velocita	45.28	5,819	641	205.1	57,978	6,029	72.6
Asus B560-F Gaming Wi-Fi	44.88	5,854	637	204.3	58,570	6,032	71.9

	CPU-Z	CPU-Z	Peak Power Consumption	AS SSD			
	Multi Thread Score	Single Thread Score	povray package power hwinfo	Sequential Read MB/s	Sequential Write MB/s	4K Read MB/s	4K Write MB/s
Asus TUF Gaming [illegible]	6,643	694	200	5,625	3,947	79.4	180.0
MSI B560i Gaming [illegible]	6,637	708	211	5,562	3,962	73.3	176.4
Asrock Z590 PG Velocita	6,642	704	202	5,426	3,870	66.4	185.2
Asus B560-F Gaming Wi-Fi	6,620	700	208	5,583	3,848	75.8	186.5

	VRM Temperature	3DMark TimeSpy Extreme		Civilization VI			Ghost Recon: Breakpoint
	10 minutes of CB R20	Overall score	CPU Score	1080p, Ultra, DX12, Avg FPS	1080p, Ultra, DX12, Min FPS	1080p, Ultra, DX12, AI Turn Time	1080p, Low, Avg FPS
Asus TUF Gaming Z590-Plus Wifi	55	8,178	5,737	241	172	7.83	187
MSI B560i Gaming Edge Wifi	73	8,144	5,707	242	172	7.81	190
Asrock Z590 PG Velocita	60	8,220	5,807	238	173	7.87	187
Asus B560-F Gaming Wi-Fi	63	8,281	5,884	240	171	7.82	189

	Metro: Exodus		Middle Earth: Shadow Of War	Far Cry New Dawn		3DMark TimeSpy	
	1080p, Ultra, DX12, Avg FPS	1080p, Ultra, DX12, Min FPS	1080p, Lowest Preset, Avg FPS	4K Ultra Preset Avg FPS	4K Ultra Preset Min FPS	Overall score	CPU Score
Asus TUF Gaming Z590-Plus Wifi	122.8	60.2	241	99	84	16,294	11,700
MSI B560i Gaming [illegible]	123.8	62.3	245	100	85	16,202	11,684
Asrock Z590 PG Velocita	122.9	61.8	240	99	84	16,356	11,862
Asus B560-F Gaming Wi-Fi	123.1	62.8	244	99	85	16,560	11,904

apc HOT PRODUCT

$239 | www.intel.com

Intel Core i5-11400F

Redefining the budget CPU market.

11th Gen CPUs may not have upended the marketplace like we hoped they would, but that perception was framed by our review of the flagship 11900K. It's powerful, but it was generally a let down due to its step backwards in core count and its runaway power consumption. The 11600K fares a lot better, but now it's time to look at the budget end of the market. The Core i5-11400F is the most affordable Rocket Lake CPU. It's a 6-core/12-thread design with a 65W TDP. It includes the improved IPC of Rocket Lake while doing away with the crazy power consumption of the 8-core models. Then there's the price. At around $239 at the time of writing, the 11400F offers stunning value for money. Is it the new budget champion? To save you from skipping forward to the conclusion, the answer is definitely yes.

The F in 11400F denotes the lack of integrated graphics, meaning you'll need a discrete GPU. It comes with a very basic cooler. In addition to the enhanced IPC and PCIe 4.0 support, you get hardware accelerated Deep Learning functions and AVX-512 instruction support, though the latter are of limited use to a budget buyer or gamer at this point in time. The 11400F features a 2.6GHz base clock and a 4.4GHz boost clock. These relatively low clocks are the reason it gets a 65W TDP. That's the PL1 figure though. Under stock operation, the CPU can boost up to 4.4GHz for 28 seconds, with a peak of 154W which is high for a budget CPU. It would have been interesting to see how 10nm Rocket Lake performed! It's well within the capabilities of a decent mid-range cooler though. Many motherboards will set longer boost durations by default and we decided to leave it like this for our testing. We saw a peak power consumption reading of 149W, which is higher than we'd like, but when compared to 8-core Rocket Lake, it's downright thrifty.

The 11400F competes very well with Intel's 8th, 9th and 10th generation 6-core models. It beats the 6C/12T i7-8700K and i5-10600K and it destroys the likes of the non-hyperthreaded 8600K and 9600K. AMD doesn't have a logical competitor. The Ryzen 5 5600X is twice the price while the likes of the 3600 and 3600X are becoming more difficult to find. The global semiconductor shortage is not helping AMD. Intel is fortunate to own its own fabs, and as long as it can keep supply up, for now, it rules the budget CPU market. Can you believe it? AMD's 5000 series are better buys at the high end while Intel's 10th and 11th Gen i5s are the budget picks. How times have changed!

The 11400F offers amazing gaming performance, especially when you loosen the power limits and ditch the bundled cooler for something more capable. If you're a gamer on a budget, you're far better off saving a few hundred over a high-end CPU and putting it towards a better GPU or a bigger PCIe 4.0 SSD. It drives our reference RTX 3080 without breaking a sweat. It's not perfect though. At full load, power consumption is still too high for a budget CPU, but it is manageable. That aside, the 11400F is the best budget CPU on the market.
CHRIS SZEWCZYK

SPECS
LGA 1200 socket; 6 cores/12 threads; 2.6GHz base clock, up to 4.4GHz boost clock; 12MB Cache; Supports DDR4-3200; 65W TDP.

The 11400F offers stunning performance for its price. It's the new budget CPU champion.
★★★★★

Best result
On test

	AMD Ryzen 7 5800X	AMD Ryzen 7 3700X	Intel Core i5-10600K	Intel Core i5-11600K	Intel Core i5-11400F
Cinebench 20 - Multi thread Score	6,023	4,858	3,473	4,281	3,935
Cinebench 20 - Single thread Score	622	509	493	594	[illegible]
3DMark TimeSpy Extreme - Overall score	[illegible]	7,806	7,304	7,631	[illegible]
3DMark TimeSpy Extreme - CPU score	[illegible]	4,583	3,652	4,323	[illegible]

The best alternatives to Photoshop

Image editing options from beyond Adobe.

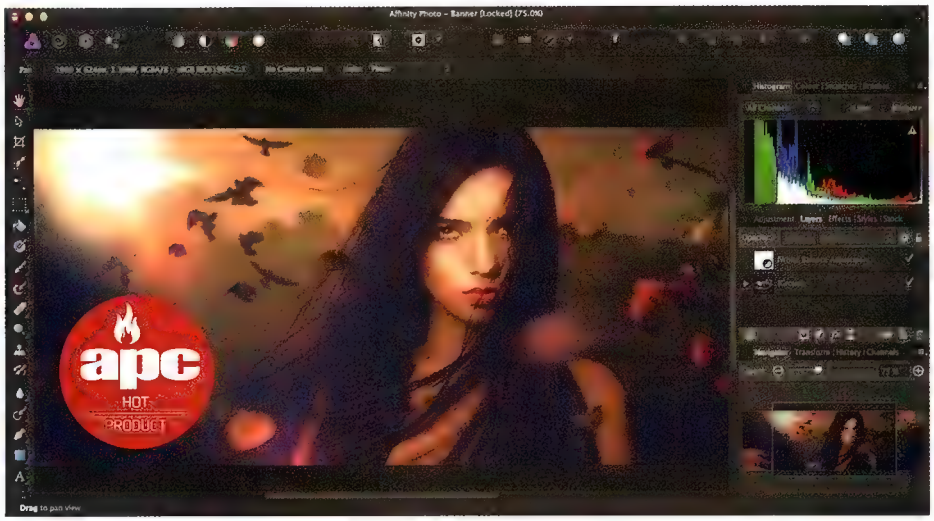
Are you looking for the best alternatives to Photoshop? Think the software is expensive and hard to use? Well, you're not alone. Launched as early as 1990, Adobe Photoshop is one of the oldest and most popular photo editing tools in the market. It's currently part of Creative Cloud, a recurring cloud-based subscription from Adobe for creative professionals.

Since its inception, Creative Cloud's pricing model has been controversial. Photoshop alone costs $29.99 a month or $343.07 a year, with no one-time purchase option available. The idea of having to pay for a monthly subscription doesn't sit right with many early-career professionals and small businesses, who have been switching to competitors offering more generous pricing plans.

We think that Affinity Photo is the best overall alternative to Photoshop. It costs significantly less without sacrificing any of the advanced functionality. It is also developed by Serif, the company responsible for the highly popular Adobe Illustrator alternative, Affinity Designer.

Users who are open to a cheaper – but still subscription-based – option may also consider Capture One Pro. Meanwhile, Corel Paintshop Pro is an excellent tool that allows you to switch between vector and raster workspaces, and Cyberlink PhotoDirector is an Adobe Lightroom-alternative with features akin to Photoshop.

Finally, Luminar AI is a great photo editing tool that uses artificial intelligence to make the process as beginner-friendly as possible.



Affinity Photo

1 Affinity Photo

The best alternative to Adobe Photoshop.

$38.99 | affinity.serif.com/en-gb/photo

Affinity Photo is the best image manipulation tool to rival Photoshop. It comes from Serif, a software company that used to focus primarily on desktop publishing tools. With the Affinity product line, however, Serif has completely outdone itself with multi-platform support, in-depth features, and affordable pricing.

Feature-wise, Affinity Photo comes with best-in-class tools for layering, masking, and retouching images. It boasts real-time rendering capabilities where effects are applied immediately at the press of a button. However, as an advanced raster image editing tool, Affinity Photo is not

particularly beginner-friendly. The interface is very similar to Photoshop's, so there are no instant presets that you can apply in a jiffy and no cataloguing tools to make file sorting easier.

Highly affordable, many advanced features, real-time rendering, no preset effects, no browsing or cataloguing tools.

★★★★½

2 Capture One Pro

Premium subscription-based alternative.

$21/month | www.captureone.com/en

Capture One Pro is an excellent photo editing tool that's better described as an alternative to Adobe Lightroom rather than Photoshop. Unlike Photoshop, Capture One is a piece of non-destructive image manipulation software that comes with cataloguing tools and built-in presets. However, those wanting more in-depth manipulation can make manual adjustments through layers and masks.

Capture One Pro features seamless RAW processing, meaning that you can add RAW files straight from your camera without having to process it into a PNG or JPEG. Although its RAW support for different camera brands isn't as extensive as Adobe's, the images produced are sharper and less noisy than in Photoshop. Other features include a modular interface that can be customised to your liking, and a keywording tool to help you tag images.

Capture One Pro costs $21 a month for a subscription. This includes support for most camera brands. It is available for both Windows and macOS operating systems.

RAW image support, advanced colour editing, layer manipulation, expensive, doesn't support all cameras.

★★★★½

3 Corel Paintshop Pro

No-frills image editing with touch support.

$119 | www.paintshoppro.com

Photoshop may be the most advanced image manipulation tool in the market, but the fact remains that most people end up using less than half of the features it offers. Corel Paintshop Pro is a budget-friendly alternative that focuses on the essentials of image editing and offers an assortment of textures, backgrounds, and brushes for you to work with.

Feature-wise, Corel Paintshop Pro doesn't break new ground. However, it does an excellent job of delivering the essentials in a user-friendly format for beginners. Since 2020, Corel Paintshop Pro now comes with a dedicated photography workspace. This new workspace is completely touchscreen-ready, and comes with effects that can be applied with just one click.

Corel Paintshop Pro costs a one-time fee of $119, and comes with a 30-day money-back guarantee. With it, you gain access to a variety of AI-enabled presets, 360-degree photo editing, and the new SmartClone tool, which uses content-aware cloning to seamlessly merge different elements together. You can also buy Corel Paintshop Pro Ultimate for $149, which throws in additional tools like AfterShot, Corel Painter Essentials, and PhotoMirage Express.

AI-enabled presets, lots of brushes and backgrounds, smartClone technology, slow rendering, no macOS support.

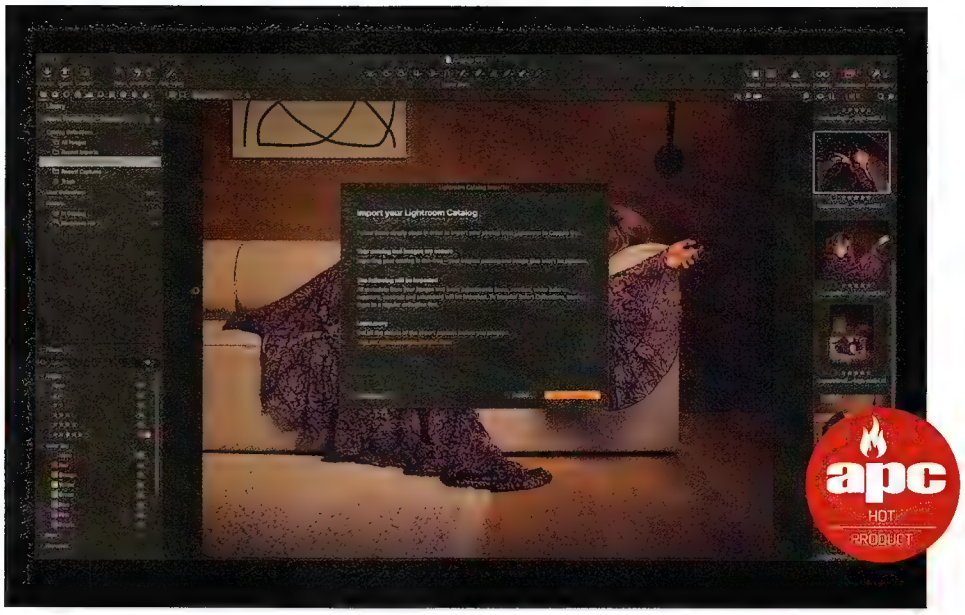
★★★★½

4 CyberLink PhotoDirector

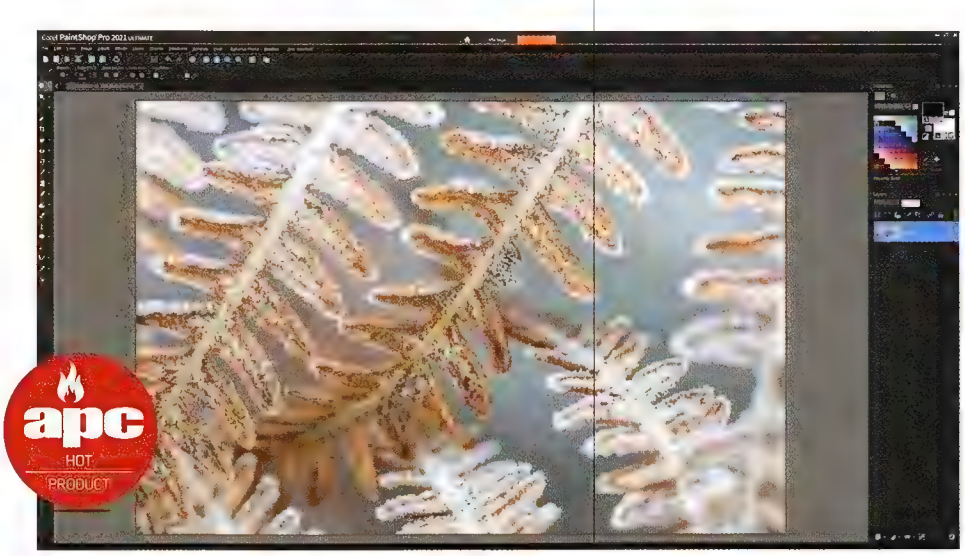
Multipurpose alternative with guided edits.

$48.99/month | www.cyberlink.com

While CyberLink started out as a Lightroom alternative, it has since grown to become an all-inclusive replacement for Adobe Lightroom, Photoshop, and Photoshop Elements. The all-in-one image manipulation software features a smooth unified interface and plenty of advanced tools to set you up on your path to photo editing. It comes with a growing collection of animations, stock images, masks,



Capture One Pro.



Corel Paintshop Pro.

filters, and more.

A very useful feature worth considering for beginners is guided edits. Those new to the software can take advantage of an array of interactive built-in tutorials to get better acquainted with the system. If purchased as a subscription, PhotoDirector also includes access to Shutterstock's library of stock images and other creative assets. However, users who purchase with a one-time fee will not be able to take advantage of the stock library.

CyberLink PhotoDirector costs $48.99 a month. If you'd like to try before you buy, a one-month free trial is available in exchange for your email address.

Stock library, guided edits, smooth UI, not enough lens profiles, fewer editing tools.

★★★★☆

5 Luminar AI

AI-powered Photoshop alternative.

From $108 | skylum.com

Luminar AI is an application designed for those who require more in-depth customisation than what's offered by basic image editing tools, but who don't have the technical expertise to make it happen. As the world's first and only photo editor powered entirely by artificial intelligence, it bridges the gap between basic image editing apps like Photoshop Elements and advanced image software like Photoshop.

If you're looking for features that offer maximum flexibility and manual customisation, you're out of luck. However, Luminar AI does offer an extensive collection of automatic effects that can turn any ordinary image into a cover photo. You can do things like replace the sky, change the weather, fix skin blemishes, adjust colour balance, and more – all with the power of AI. You can even apply an automated overall fix to make your image look more professional.

The AI effects blend in seamlessly, but Luminar AI does have its downsides: it suffers from a complete lack of cataloguing options, and the rendering performance could be better.

The software comes in three packages: Master, Expert, and Guru. You can go for a one or two-computer license. Prices range between $108 and $291 for one device and $139 to $322 for two devices. All packages come with a lifetime license, 30-day money back guarantee, and 24/7 technical support.

AI-powered, preset library, automatic touch-ups, inconsistent performance, no cataloguing tools.

★★★★☆

CyberLink PhotoDirector.

"If you are looking for an all-encompassing Photoshop alternative with the exact same features and a better price range, Affinity Photo is probably the best choice for you."

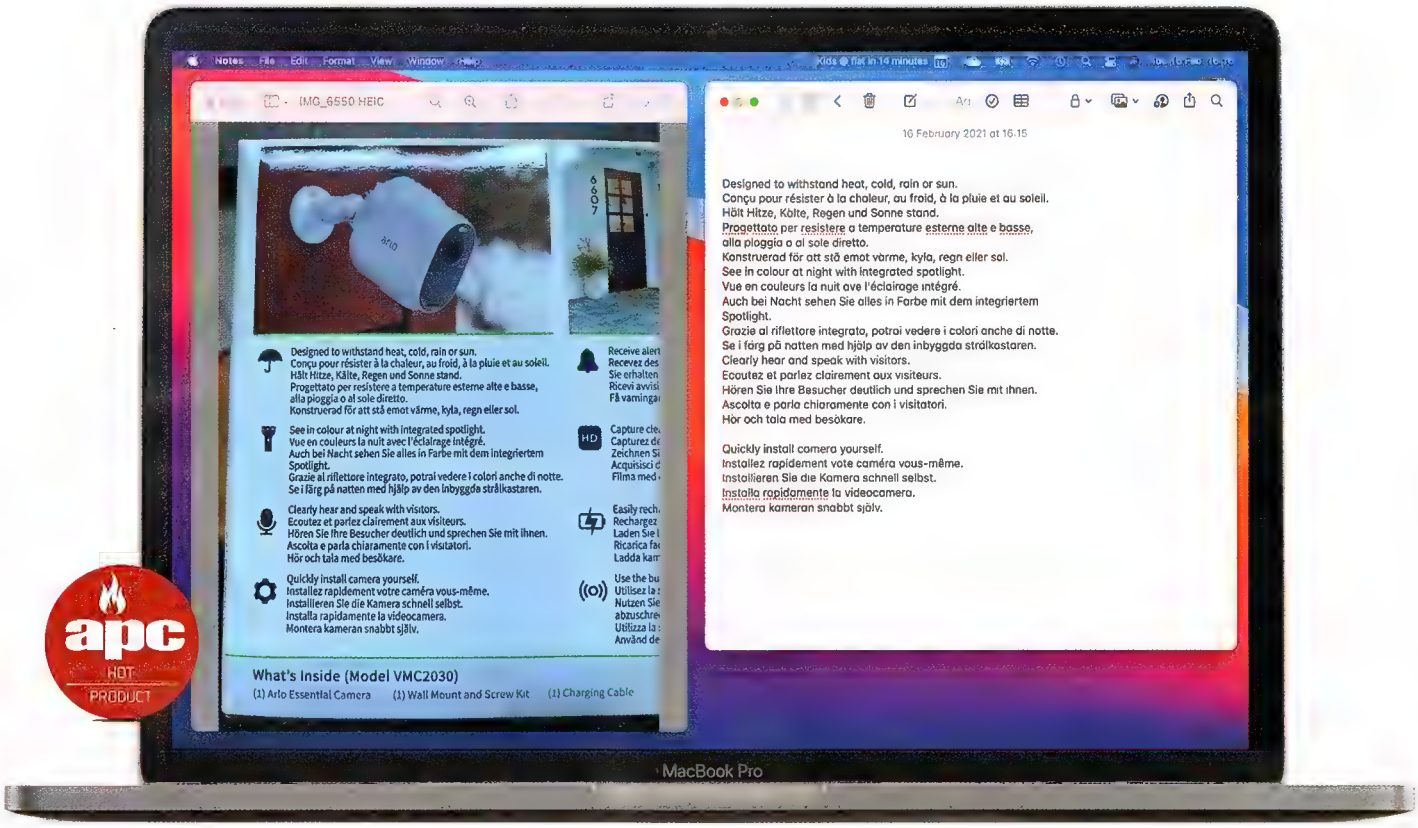
Conclusion

Photoshop is an image manipulation tool that allows you to edit and enhance raster images using a series of manual and automatic techniques. If you are looking for an all-encompassing Photoshop alternative with the exact same features and a better price range, Affinity Photo is probably the best choice for you.

Otherwise, the best alternative will depend largely on your specific requirements. For example, Capture One is an excellent choice for those looking for a Lightroom-esque photo editor, whereas those requiring touch support and the ability to switch between raster and vector formats may choose Corel Paintshop Pro.

CyberLink PhotoDirector is a good choice for beginners thanks to its guided edits feature, while Luminar AI is for those who want a completely automated workflow.

Luminar AI.



Needs macOS 10.15 or later | $14.99 | textsniper.app

TextSniper

Incredibly fast image OCR.

Scanning text so you can edit it, quote it or reuse it can be a pain, and the apps that do it can cost a lot of money. Not here. TextSniper can extract and recognise text from anything you can see on your Mac's screen and it does it incredibly quickly. It's cheap, too.

Not all of the text we see on our displays can be copied via traditional cut and paste. Celebrities' insincere apologies screenshotted in Notes and shared on social media; text with graphics behind it; scanned or photographed documents such as legal decisions or old newspaper articles; app dialog boxes and options; recipes shown on video; text from presentations or displayed in embedded document readers; text from uneditable PDFs… it's a very long list, and if you're involved in things like writing training courses, tutorials, documentation or how-tos you'll have encountered quite a few of them. TextSniper can handle them all. It can also read bar codes and convert QR codes.

When you run TextSniper it puts a little icon in the menu bar and gives you a new keyboard shortcut: command-up arrow-2. Simply activate the shortcut or select Capture Text from the icon drop-down and draw the selection rectangle over the text you want to recognise. You'll see a thumbs-up icon and the message Copied To Clipboard. You can then paste the recognised text into your document.

The whole process is incredibly fast. We've tried TextSniper on an M1 Mac and on an ageing iMac and it delivered instant results immediately on both machines. And it's accurate too: provided the source text doesn't get involved in too much design madness or hasn't been through 15 photocopiers it copes admirably with coloured text, outlined text, text with umlauts and accents and even very small print. We chucked page after page of PDFs, tweeted images, scans and anything else we could think of at it and it achieved exceptional accuracy even when the text was a little blurry or in multiple languages. If you find it doesn't recognise particular words, such as legal or medical terms, you can add them to the custom dictionary so it'll use the correct results in future.

Recognition is lightning fast, very accurate and copes well with non-English characters.

TextSniper sits unobtrusively in your menu bar.

By default, each new copy replaces what's already in the clipboard, but you can set it to an additive clipboard that appends new text to what's already there. You can also use the app as a fast text to speech reader.

The app isn't perfect: it's purely for text and can get a bit confused with symbols and other design elements, and from time to time it did strange things with line breaks. But these are minor flaws in an otherwise exceptional app that does something small but incredibly useful. Not everybody needs it, but the people who do will love it.
CARRIE MARSHALL

TextSniper is small, speedy and could save you lots of time and frustration.
★★★★★

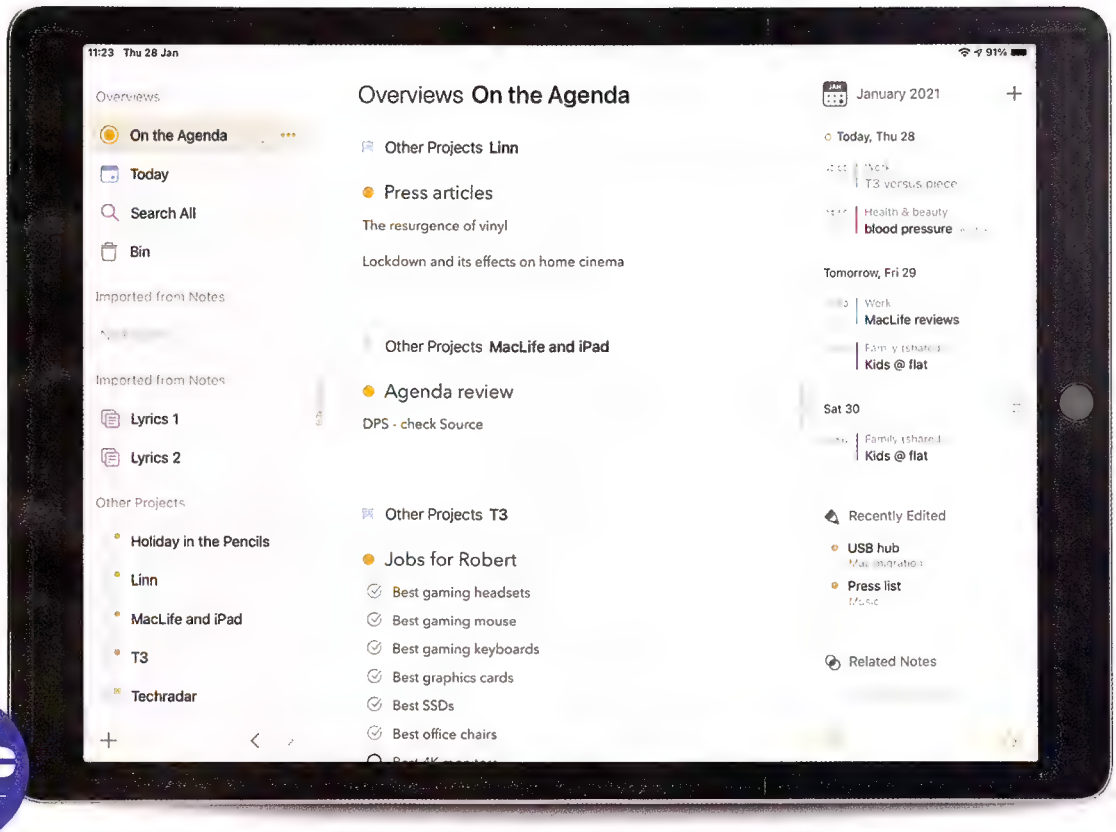
PC GAMER

THE GLOBAL AUTHORITY ON PC GAMES

Over 22 million gamers visit us online every month.

Join them.

www.pcgamer.com



Needs iOS 11 or later | Free (IAPs) | agenda.com

Agenda 12

An app that makes organising easy.

This app combines notes, calendars, and reminders. Agenda notes can contain pretty much anything, and you can organise notes by category, project, dates or tags.

There are two versions of Agenda: a free version that you can use forever and the Premium iteration, which for a one-off $54.99 unlocks features such as project archiving, creating smart overviews from search criteria, copying text as Markdown/HTML, and editing Calendar events. The free version is good but Premium, which also covers your Mac, is better.

Agenda uses a three-panel layout. The left sidebar contains On The Agenda – a bird's-eye view of your most important notes – as well as a Today view, a Search link, and direct links to your projects. You can create different categories for different kinds of projects. The right sidebar shows the calendar, links to recently edited notes, and notes that are related to the one you're currently looking at. The left and right sidebars can be summoned or dismissed with a single swipe. And you can use your Apple Pencil on supported iPads for handwriting recognition, to select text or other items, and to interact with the interface.

The editor in Agenda is a style-based text editor that enables you to format text and add tags, links, tables, lists, and check boxes. Tables are new to version 12 and in the Mac app support inline styles; on the iPad you're limited to basic formatting.

The editor looks minimal but if you tap on the gear icon in a note you'll get the copy, move, share, and save as template options. The Copy As feature enables you to copy your notes in Markdown or HTML format to preserve your formatting and links. Similarly, the '+' button on the formatting toolbar gives you options for attaching files, adding tags, setting dates and reminders, importing photos, or using the iOS document scanner. You don't get the same extensive formatting options that you would find in the likes of Evernote, but you do get multiple heading styles, code blocks, lists, and check boxes. It's easy to assign notes to a particular date or time, and if you tap on calendar items in the sidebar you can quickly add a new note, reschedule the event, or edit the event details without having to open Calendar itself.

Agenda – diary, project manager, writing app or a mix of all three.

The formatting options aren't particularly extensive here but they cover the essentials.

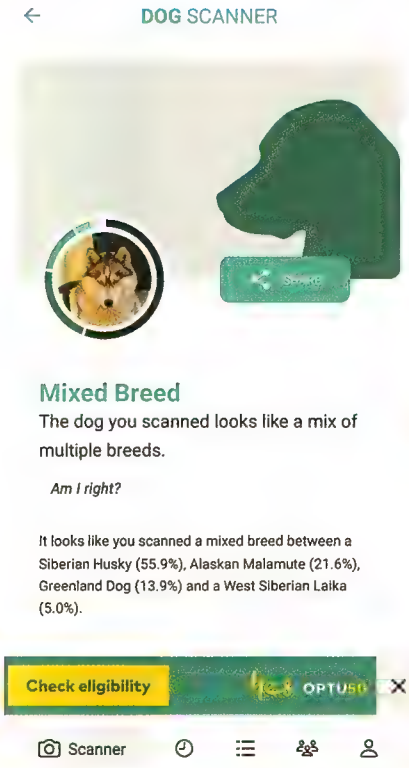
Agenda also gives you the ability to link to things from your notes. You can create Agenda Links, which enable you to add shortcuts to existing Agenda notes, and you can attach external files. Attached files are synced between your different devices via iCloud or Dropbox and you can change how they display on a per-note basis.

If you're currently mixing and matching notes, as well as to-do, reminder and project apps, or you just need to stay on top of all kinds of stuff, Agenda is a powerful way to stay organised.

CARRIE MARSHALL

A great mix of note-taking and scheduling.

★★★★☆



Android | Free/$24.99

Dog Scanner – Dog Breed Identification

About as good as guessing.

We've scanned plants and rocks, now it's time to identify some furrier friends. Dog Scanner boasts being able to identify dogs based on their photographs. To do this either upload or take a picture with the app – you can choose more than one if you have them. Dog Scanner will then spit out its estimate, and like most of these apps it's... ok at best. Every dog I've scanned has come out as 'mixed breed' which is the best dodge of confidence I've seen yet. It does give percentage based options for what those breeds might be, and credit to it husky was the first result for my very obvious husky. However, it had no idea about less common dogs like my white shepherd. As with these things it may learn with time, and it does have a forum section to get other users' input. Unfortunately, this social aspect of the app is also already full of bots posting ads, so I don't have a lot of hope.

★★☆☆☆

HOPE CORRIGAN

Android | Free

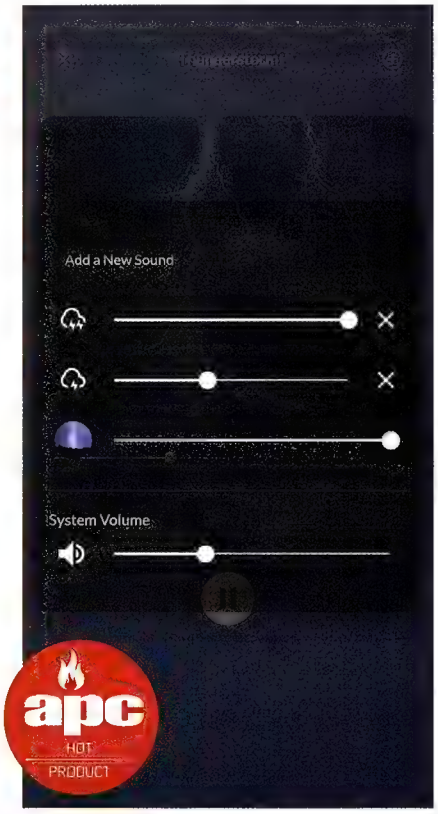
3D Saxophone Fingering Chart

Learn a new instrument.

Looking into apps that teach Saxophone I found one thing wanting in particular. Fingering refers to the buttons on the saxophone that need to be pushed to get certain notes. This seems straightforward but there are a surprising number of random keys on a sax, some of which most players will never use. The very top key on a saxophone, and where many players instinctively put their fingers, is one such appendix of a key. Most diagrams don't make this obvious enough and many players could easily be put off before they start. That's why a good clear chart is important. Despite looking very basic, this is the best I found for clarity. It always shows a full yet simplified saxophone rendering with hands that can be toggled on or off. The keys also become coloured so you can actually see what the hands are pushing. It even has some high octave notes that experienced players may wanna check on, so it has uses for many skill levels.

★★★★★

HOPE CORRIGAN



Android | Free/playpass/$49.99

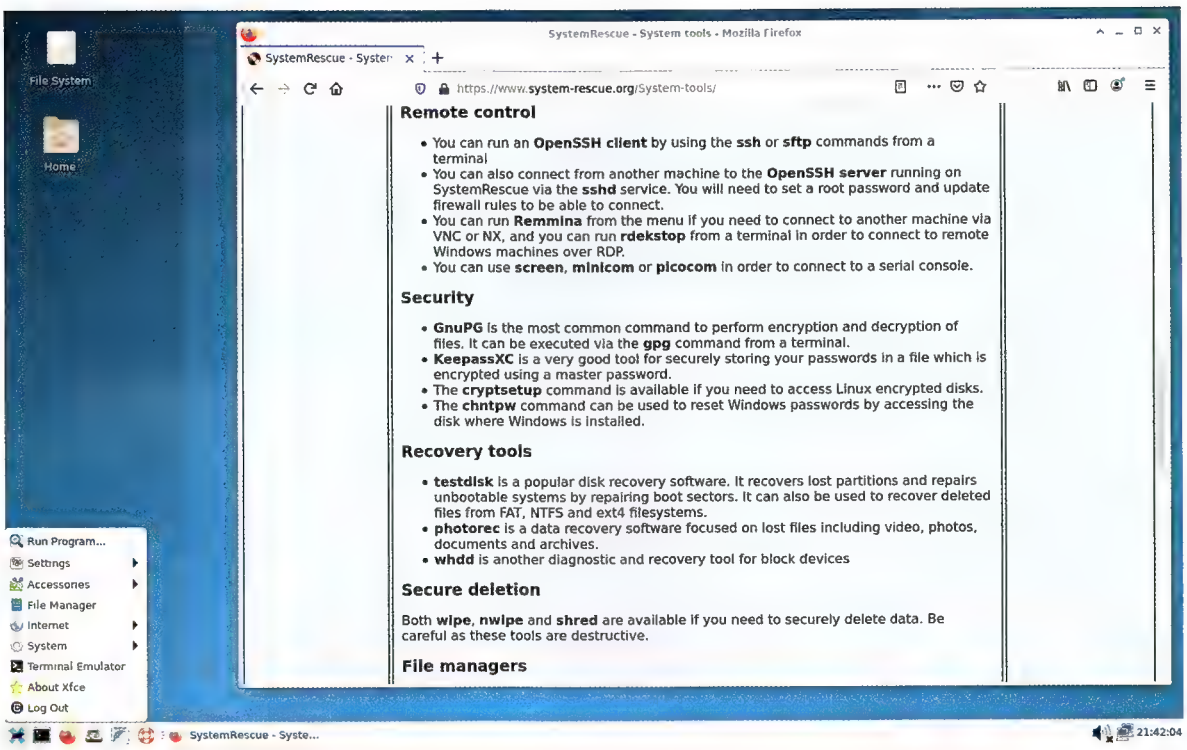
Sleep Sounds

More than snoring.

Apps to help you sleep are a dime a dozen and litter the stores, so I'm always keeping my eyes closed for the best ones. I saw an advert for Sleep Sounds being pushed so I figured I'd check it out, and I'm quietly impressed. This gives a wide range of options for almost anything you could hope to listen to falling asleep. But where it really shines is in all the little customisations. You can layer the sounds, so if a thunderstorm isn't really doing it for you, you can add more thunder, or perhaps some bird sounds, or even music. You can even create custom tracks and play lengths to suit your needs. That dime a dozen comment wasn't for nothing. Most of these apps try to get money for every little feature but Sleep Sounds does a lot at little cost, or everything for free if you have a play pass sub. Well worth looking into for some relaxing ambiance.

★★★★★

HOPE CORRIGAN



Linux | http://system-rescue.org

SystemRescue 8.0

If you're as adventurous with your installations as Mayank Sharma, then you too would want to keep a copy of this distro handy...

One of the most popular rescue distros, the project has undergone several major changes of late. The earlier Gentoo-based edition of the distro had a compressive boot menu, which was dropped when the distro rebased to Arch. It's since added several options to the boot menu that help address a range of use cases and rescue scenarios.

There are the usual options that you also get on other distros, such as the option to copy the entire system to RAM, another to boot and verify the checksum, and one to use nomodeset to help resolve display issues. The first interesting option is the nofirewall parameter that disables the iptables service. This enables you to connect to SystemRescue-powered computer remotely from over the network with SSH.

If you want to manage SystemRescue remotely you should also set a password for the root user with the rootpass or rootcryptpass options, with the latter enabling you to specify an encrypted password.

Another unique aspect of the distro that was recently reintroduced is the use of SRMs or SystemRescue Modules. These are squashfs file system images that can be used to add custom data files such as scripts and even additional tools. Experienced admins can use SRMs to customise their SystemRescue environment as per their needs.

The default boot option will boot SystemRescue to a console, which lists the command to configure the keyboard layout and start the graphical environment. And that's perhaps the only downside of the distro, in that it doesn't offer much in terms of a tailored interface to help you rescue your installation.

The distro uses the Xfce desktop and houses a handful of essential productivity tools in its menus such as Firefox, but that's about it. Unlike some of its peers SystemRescue doesn't try to hand-hold the users through any of the rescue processes. For instance, Rescuezilla presents an intuitive custom interface to help users set up their disk imaging tasks. Similarly, Ultimate Boot CD has an elaborate boot menu to help users narrow down the tool they need to use for the rescue task at hand.

You get none of these conveniences with SystemRescue. Instead there's a whole lot of tools that can help you wriggle your installations out of all kinds of issues. The distro packs several repair and rescue tools and utilities and supports all the common and important file systems. You can, for instance, use it to rectify all sorts of issues with hard disks, including sorting the MBR and restoring the partition table. It'll also save the contents of the filesystem on disks on their deathbed to a compressed archive, and can even securely delete files and recover accidentally deleted ones. The distro also packs tools to work its magic on Windows partitions for everything from resetting passwords to rescuing data from an unbootable Windows machine.

Besides the official documentation, SystemRescue also has a comprehensive hands-on guide that's available for the Kindle.

All things considered, SystemRescue is designed for experienced campaigners who know what they are doing and are familiar with the tools and know how to operate them when there's an emergency.

In terms of documentation, the distro's website hosts a quick start guide as well as detailed instructions on basic and advanced use. There's also instructions for advanced users, such as the guide to create custom SRMs with Arch's pacman packages.

A well-rounded recovery solution that will help resolve most common issues as long as you know how to operate its tools.
★★★☆☆

A Lorenz SZ42 cipher machine on display at Bletchley Park museum.

© JACK TAYLOR/GETTY IMAGES

A COLOSSAL SECRET

Ian Evenden discovers how British WWII braniacs, faced with an impossible task, helped save millions of lives and invented the computer as we know it.

Your country is at war, and you start picking up directional radio signals that sound like nothing you've ever heard before. The enemy is highly mechanised, makes use of the latest technology, and has a record of using complex codes and ciphers in its transmissions. This is something new, however. Instead of the dots and dashes of the Morse code you're used to intercepting, this sounds like a harsh wailing.

These days, we'd probably equate the sound with a 56K modem, but back in the 1940s, it was known as teleprinter code. Nazi high command, not content with the "unbreakable" Enigma cipher it used to spread orders among its armies and navies, was also using a machine for higher-level communications called the Lorenz SZ that British codebreakers had never seen, and would not see until the end of World War II. Despite this, they were able to deduce how it worked, and crack the encipherment.

This is the story of a country house in England full of mathematicians, crossword enthusiasts, the occasional genius, and a man from the postal service more used to creating automated telephone exchanges. Together, they read German military communications and shortened WWII by up to four years, saved possibly millions of lives, and created Colossus, the first programmable electronic computer, in the process.

This is a complicated story, and we've had to leave bits out, but bear with us, there's still a lot of backstory. The tale of how the British, Alan Turing in particular, cracked Enigma, opening up Nazi communications, and making it possible to anticipate their every move is already fairly well known, but it has some parallels with the decryption of the Lorenz machine that can't be ignored. The Nazis had mechanised the sending of secret messages, so a mechanised approach was needed for reading them. Lorenz had similar weaknesses to the Enigma, especially if you could be confident of the content of certain parts of messages, such as ending everything with "Heil Hitler," for example.

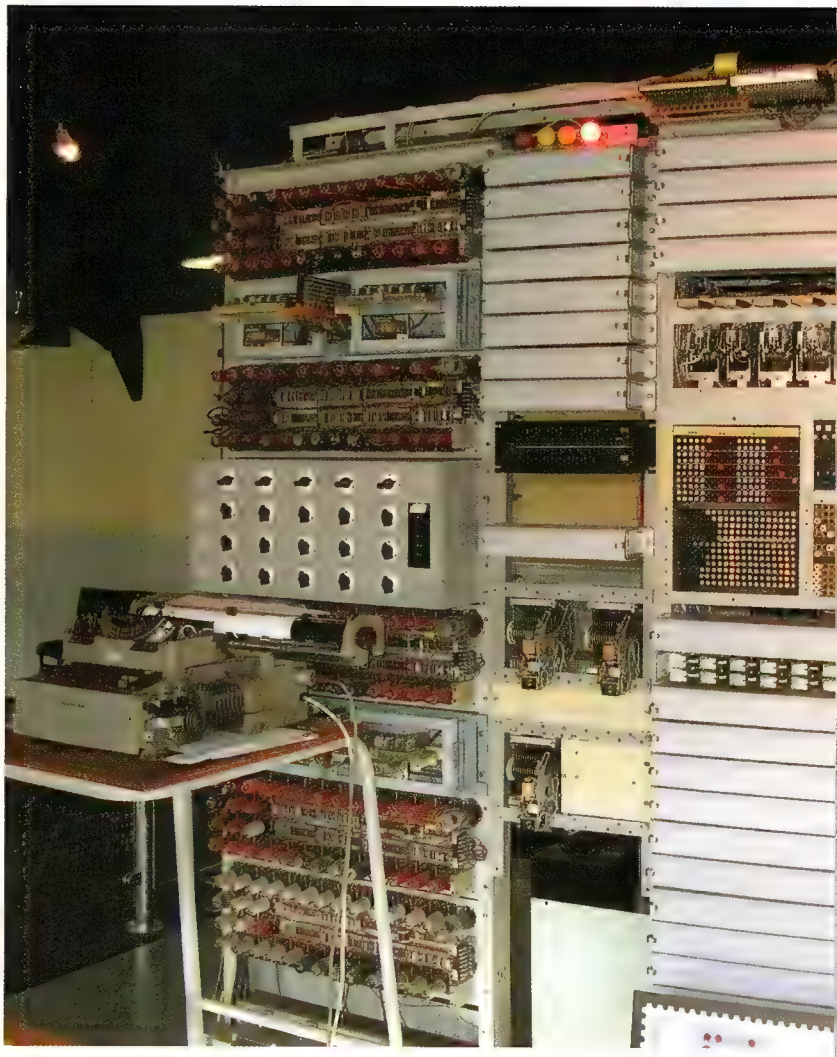
Enigma was an electro-mechanical machine with three, sometimes four, rotor wheels and a plugboard. Input came from a keyboard, and its output was a lamp that lit up behind a grid of letters. The rotors moved every time a key was pressed, one full rotation triggering the next one to move, then the next. The plugboard swapped letters over, so connecting A to S always switched those letters. With three rotors from a set of five in use, and 10 connections on the plugboard, the machine was capable of nearly 159 quintillion (18 zeroes) combinations. Adding a fourth rotor, as the German Navy did, just made things worse.

Lorenz had 12 rotors, and acted as an add-on to a teleprinter machine (you type at one end, the message comes out printed on paper tape at the other), but otherwise operated in a similar way. Once the machine's settings for the day were entered, however, it was much more automatic. The enciphered text was encoded as a 5-bit Baudot code (International Telegraph Alphabet No. 2) for transmission, which made use of a modulated on/off signal – binary, in other words – that was the source of the modem-like screeching the British listening stations were picking up.

"It was a binary machine, but not understood as a binary machine," says Paul Gannon, author of Colossus: Bletchley Park's Greatest Secret. "They used a different terminology at the time – mark and space. They didn't think of it as zero and one; that's a backward projection from what we know now."

The Lorenz machine then encrypted the Baudot further with a Verman stream cipher. Ten of the 12 rotors in the machine generated a key stream in two groups of five, which was combined with the plaintext using a logical operation known as Exclusive Or (XOR). The remaining two wheels added a pseudorandom "stutter" to the key stream, complicating it further. Each rotor had a different number of cams on it, which could be raised or lowered to create the wheel settings. The total number of settings is a number so large it would be followed by 150 zeroes (there's 18 in a quintillion, remember).

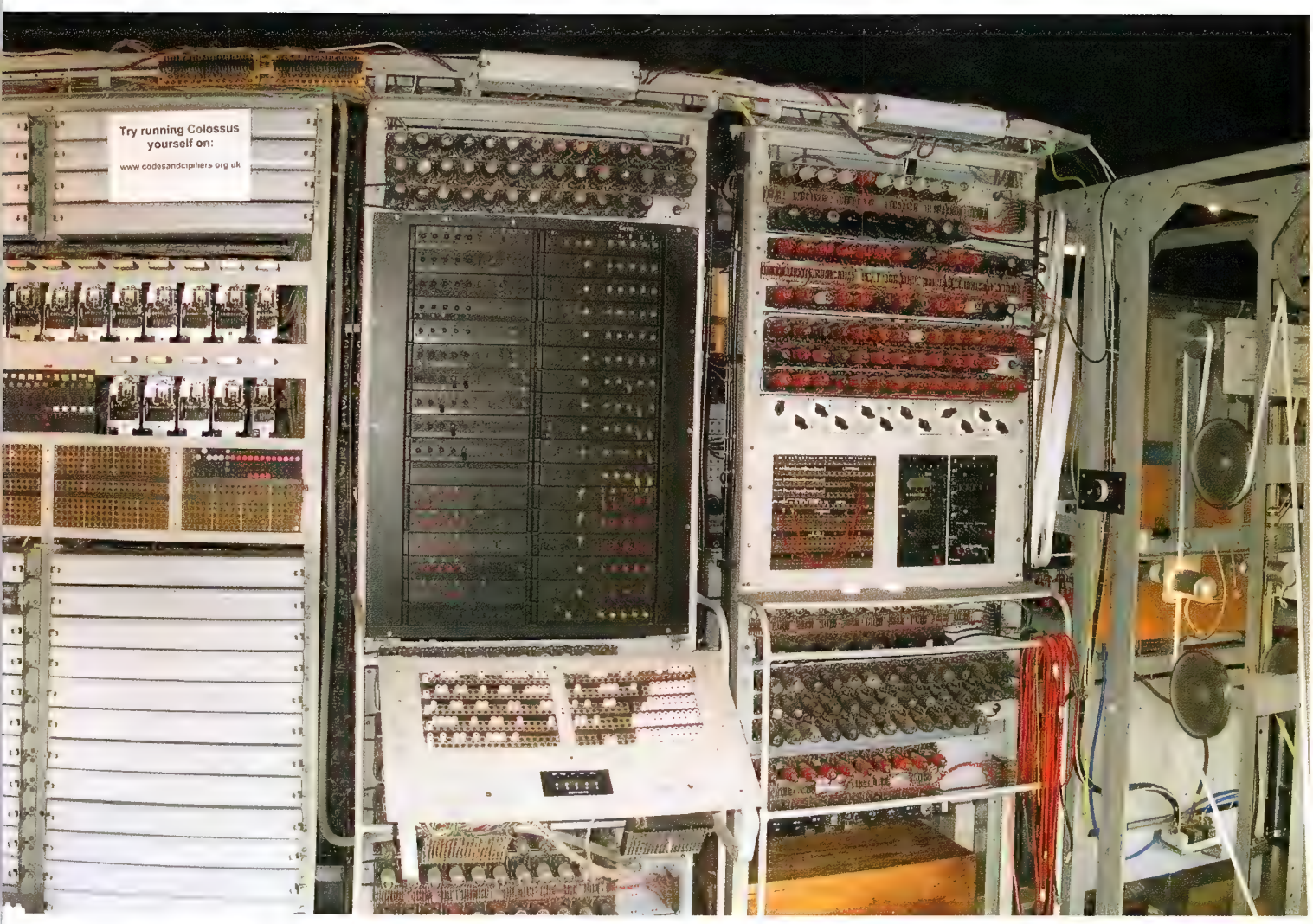
"There's no reason why it had to be like this," says Gannon, "but with Enigma they would write the message down on a piece of paper, one guy would then read out the message, another would type in each letter of the message and read off the encoded letter, then write it down. Then somebody else would transmit that using Morse code. At the other end, they would read the Morse code, and reverse the message with an Enigma set up with the same settings. But the teleprinter was a central communications tool within Germany, and especially with the Nazis when they took over, and so they wanted to carry on using it. First of all they transmitted from teleprinter to teleprinter over cables, and then using a wireless link."

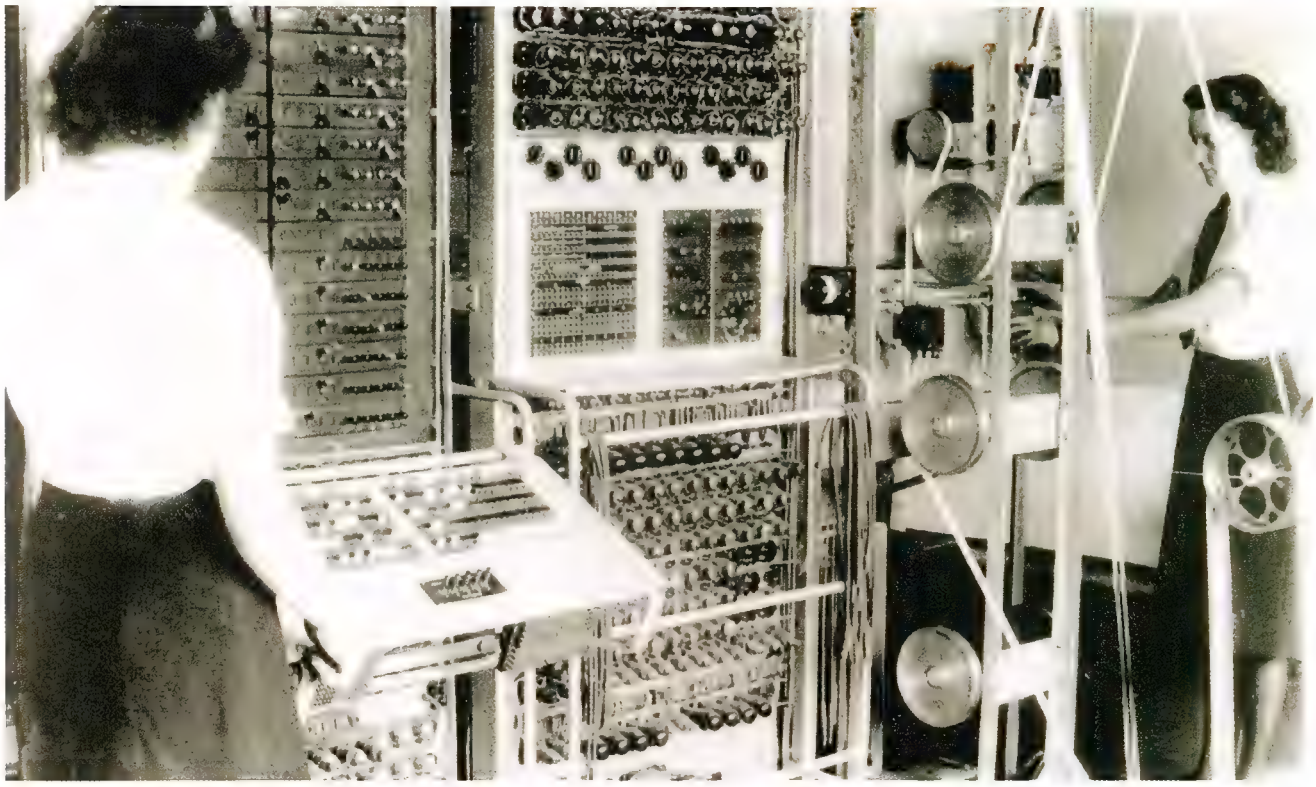


Gannon continues: "Your message was automatically encrypted and at the other end automatically decrypted, so all you needed was one typist at each end, rather than three people writing things down. Nobody saw the encrypted version of the message. The teleprinter was the key to communications within the German army, and this suited the British at the time because they had cracked the German naval and air force Enigma, but hadn't cracked the army Enigma. So when they started intercepting these weird sounds, which they described as being like a cow wailing, it took some time to work out what they were."

The first transmissions were intercepted in 1941, a link between Berlin, Germany, and Athens, Greece. Used to dealing with Morse code, the British classified these as NoMo, or non-Morse, and the Berlin-Athens link picked up the code name Tunny (tuna fish). Tunny would become the code name for the Lorenz machine itself (Geheimschreiber, or secret writer, in German) after the link closed in 1942, while the teleprinter operation as a whole became Fish. As new links sprang up, they attracted new species of sea life: Berlin to Tunis was Herring, Berlin to Paris Jellyfish, and Berlin to Oslo was given the code name Mullet. This was a recurring theme – three-rotor Enigma transmissions were code-named Dolphin, while four-rotor

Above: Frontal view of the reconstructed Colossus at The National Museum of Computing, Bletchley Park, UK.
Right: A Colossus Mark II computer being operated by Dorothy Du Boisson (left) and Elsie Booker (right), 1943.





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The Enigma machine resembled a typewriter.

The wheels in the Lorenz machine each have a series of cams that can raise or lower, which were the settings Colossus calculated.

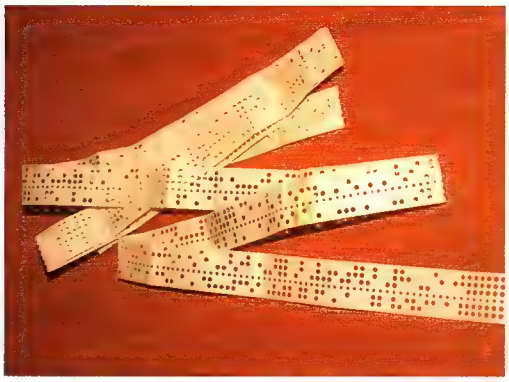
Code vs. cipher

Whether something is a code or a cipher is a question that mainly vexes magazine editors looking at almost 4,000 words of copy in which the terms are used frequently, but the two concepts are not interchangeable.

One way of looking at it is that codes change words, but ciphers change individual letters, or bits. In the context of Lorenz, the Baudot code took the words that were enciphered letter by letter by letter by the Geheimschreiber, and turned them into something else.

Another approach is that ciphers are for keeping things secret, whereas codes can be publicly known. An example here is Enigma, which was meant to be secret until Bletchley Park got its hands on it, and which used Morse code to transmit gibberish to other Enigma operators, who then transformed it back into readable German through knowledge of Morse and the secret Enigma machine.

Roman dictator Julius Caesar, though not blessed with a wireless network through which to propagate his orders, made use of a simple substitution cipher in which letters are shifted a set number of places in the alphabet. So, with a shift of five, the common phrase "Maximum PC, Minimum BS" becomes "Rfcnrzr UH, Rnsnrzr GX." You can see here an immediate weakness of a single-alphabet cipher: The words "Maximum" and "Minimum" look very similar even when enciphered. A polyalphabetic cipher, such as Enigma or Lorenz, fixes this, but Enigma had a cryptographic weakness – no letter could ever be enciphered as itself – that Lorenz didn't.



Paper tape with the punch holes of 5-bit Baudot code, and sprocket holes running down the middle.

transmissions were Shark. The intelligence gathered by codebreaking was known as Ultra, and was an incredibly closely guarded secret.

Bletchley Park, home of the innocuously named Government Code and Cipher School (think today's NSA), is a country house in the middle of England, built in the 1880s. These days, it's a museum, but during WWII, it was a branch of the British intelligence services. Its activities were so highly classified that it wasn't until 1974, with the publication of a book, *The Ultra Secret*, by F. W. Winterbotham, that details began to trickle out.

What took slightly longer to emerge, however, were the details of what they'd built there. The Enigma cipher was broken through human ingenuity (a lot of early work had been done in Poland during the 1930s, and transferred to Britain at the outbreak of war), and a series of electromechanical devices known as Bombes, which simulated the rotors of the Enigma machine and could sift through possible settings to crack that day's wheel order and plugboard connections – effectively a brute force attack but using human brainpower, some wartime heroics (such as snatching a codebook from a sinking submarine), and user errors, such as transmitting two identical messages with different settings, to lower the number of permutations necessary. Lorenz, being far more complex, required a different approach.

At this point, Thomas H. Flowers, known as Tommy, the top man in research and development at the General Post Office Research Station at Dollis Hill, London, became involved. He was the son of a bricklayer, in contrast to the middle- or upper-class types usually found at Bletchley Park, and had earned a degree in electrical engineering by taking evening classes. He'd been exploring the use of electronics in telephone exchanges – usually powered by young women before this point in time – and was convinced he could build an all-electric one.

Which is how he came to the attention of Alan Turing, who asked the Post Office for help. "The issue started really with the Enigma when the German navy introduced a fourth rotor wheel," says Gannon. "A fourth rotor was just too big a job for an electromechanical device to sort out, so they set up two or three different projects." His first project with Turing was abandoned, but Turing was impressed enough to introduce Flowers to Max Newman, who was leading the assault on Lorenz in his "Newmanry" – the part of Bletchley Park working on automation.

"Turing wasn't directly involved in the whole Tunny question," says Gannon. "But he was a general consultant on all sorts of things at Bletchley Park, so got a little bit involved well before they even came up with the idea of Colossus. When they were stuck on how to decipher the messages that they were picking up, he suggested using a technique known as the Delta."

The math involved is too much for a humble PC magazine, but it involves repeated characters (a feature of German, which is full of SS, EE, TT, and LL). The ciphertext can be manipulated in such a way that certain relationships appear between characters that wouldn't be there if it was

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From left to right: Tommy H. Flowers, telephone exchange expert and builder of the first electronic computer; Max Newman, British mathematician, codebreaker, and computer builder; C. E. Wynn-Williams, inventor of Colossus's counting device.

random, and from this the movements of one set of wheels in the Lorenz machine could be deduced. It was called Delta for the Greek letter, and the word "difference," because XOR is the same as modulo 2 subtraction.

"This became a key factor in what Colossus did," says Gannon, "as the way the Lorenz machine was built meant that two of the wheels generated an intermittent stutter in order to try to increase the periodicity of the wheels. By using the Delta technique, you could observe these stutters because you'd get a regularity, lines of spaces coming through. You could then statistically see through different layers of the cipher."

This method of attacking Lorenz was carried out in the "Testery," the part of Bletchley Park run by Ralph Tester, and supplemented by machines in the Newmanry. Flowers' first design for Newman was called the Heath Robinson (named for a British illustrator not dissimilar to Rube Goldberg), produced in conjunction with his colleague Frank Morell at the Post Office Research Station. Begun in January 1943, it was delivered to Bletchley Park in June, and worked pretty much straight away.

To understand how, we must step back a bit. In 1941, a Nazi radio operator made a mistake. He transmitted a message of 4,000 characters from Athens to Vienna using Lorenz, but it wasn't received properly. Vienna asked Athens to repeat the message, but didn't encrypt this request. The British immediately began to listen very carefully. The 4,000 characters were sent again, but without changing the key settings. This was very bad practice – in fact it, was forbidden – and to make things worse, the two messages weren't quite identical; the operator used abbreviations to make it shorter. In cryptography, this is known as a "depth," and can be used to break into the cipher.

Enter the enormous brains of Bill Tutte, a British/Canadian mathematician, and John Tiltman, a British Army intelligence officer. Tiltman deduced that it was a Vernam cipher using the XOR function, and was able to extract the key. This huge feat of intellect relied on Turing's observation that, once you had recognised and removed the effect of the first five wheels in the machine from the message, what was left, though still unreadable, was not statistically random. It took two months, but Tutte, backed by other members of the Research Section, was able to work out the complete structure of the Lorenz machine, despite never having seen one, from this one mistake by a radio operator in Athens.

It was this break-in that first Delta and then Heath Robinson were designed to exploit – removing the effect of the first five wheels from the enciphered message, so that manual methods could do the rest. It used two synchronised paper tapes for data storage (each punched with up to five holes, one for every bit of the Baudot code), and was largely electro-

XOR table

•	•	•
•	X	X
X	•	X
X	X	•

A table showing the effect of the XOR function on 1 and 0 inputs.

What was everyone else doing?

Of course, the Germans weren't the only player in 20th-century geopolitics to encrypt their messages. The British took Enigma, added some extra bits to it, and produced Typex, a seven-rotor machine that the German Beobachtungsdienst (Observation Service) of Naval Intelligence never broke into despite reading most other British radio traffic during the war.

Beobachtungsdienst was based in Berlin, however, and Allied bombing raids destroyed many of its records. This, along with the British taking up the practice of superencipherment (enciphering a message using one method, then again using another) meant that by 1944, no British ciphers in use could be read.

In the United States, the Japanese diplomatic cipher known as Purple was of more interest, and the intelligence it provided was code-named Magic. Purple was again a modified Enigma, but used stepping switches instead of rotors, and was known in Japan as the System 97 Typewriter for European Characters. The US Army Signal Intelligence Service reverse-engineered the system and had a machine that could read Purple by late 1940, but would not obtain the fragmentary remains of a genuine machine until 1945. As the Japanese ambassador in Berlin tended to brief his government in great detail using Purple (reviews of German assessments of the military situation, reports on direct inspections by the ambassador, including Normandy beach defenses, reviews of strategy and intentions, and reports of interviews with Hitler), Magic was of great interest to the British, and two of the reverse-engineered Purple machines ended up in British hands.

The Japanese naval cipher, JN-25, was trickier. Tiltman and Turing at Bletchley Park worked out quite early that it enciphered words as five-digit numbers using a codebook, then used a second codebook as superencipherment. Without the codebooks, however, they couldn't read it, and in 1940 the Japanese Navy wasn't sending many messages. But after Pearl Harbor, there was more traffic, and the Japanese habit of starting messages with "I have the honor to inform your excellency..." led to it being broken.

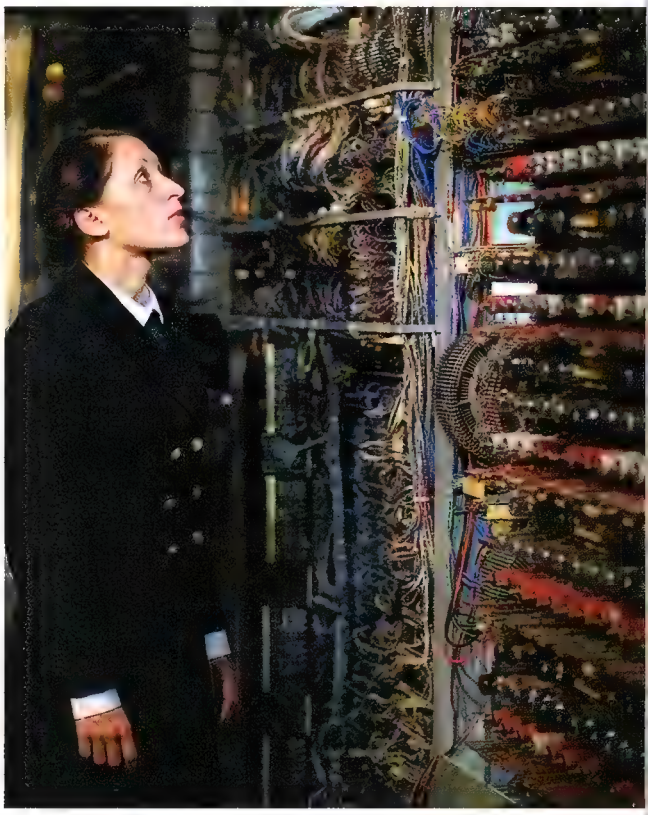
Two women at work at the US Army Signal Intelligence Service during WWII. The woman on the right is inputting ciphertext into an analog of the Japanese Type B Cipher Machine.

mechanical apart from a few thermionic valves – key components of electronics for the first half of the 20th century until the invention of the transistor. The characters of the message were punched into the paper tape, which was passed at speeds of up to 2,000 characters a second past a photoelectric reader. Flowers' valve-based "combining unit" then applied the XOR logic that Tutte had figured out, passing the result to a counting unit designed by Dr. C. E. Wynn-Williams from the Telecommunications Research Establishment at Malvern. This used a thyratron – a sort of high-voltage thermionic valve – to count the number of 0s generated. The higher the 0 count, the more likely the key sequence was correct.

The Heath Robinson was slow and a bit unreliable. Paper tapes could stretch, putting them out of sync, and the display of the 0 count was overwritten with each new count, leading to lost data if not written down in time. Many of the shortcomings were dealt with as the machine was improved, but Flowers realised he could produce a machine that generated the key stream electronically. This meant a lot more valves. The idea that up to 2,000 valves could work together reliably was not popular. They weren't seen as reliable, with a tendency to blow like old-fashioned light bulbs.

"There was a dispute between Gordon Welchman [Assistant Director for Mechanisation at Bletchley Park in 1943] and Flowers, where Welchman was trying to get Flowers kicked out of Bletchley Park because he was wanting to use too many electronics," says Gannon. "His ideas would have used up all the electronic valves in the country." Gannon's theory, based on his research, is that Turing intervened and took Flowers' side. This was just as well, as Flowers' work at the Post Office had shown that valves blew from stresses that were greatest when they were powered up. His solution? Don't turn the machine off. A team of 50 people set about building something completely new.

Colossus Mark I, with 1,600 valves, arrived at Bletchley Park on



A Colossus computer, used during World War II at Bletchley Park, on display at The National Museum of Computing in the UK.

What happened next?

BILL TUTTE became a Fellow of the Royal Society of Canada in 1958 and of the London Royal Society in 1987. He became an Officer of the Order of Canada in 2001, and has a road named for him in Waterloo, Ontario. He died in 2002.

JOHN TILTMAN was the first non-US citizen to be inducted into the NSA Hall of Fame. He was awarded the British honors OBE, CBE, and Most Distinguished Order of Saint Michael and Saint George, as well as the Legion of Merit from the US Armed Forces. A consultant for the NSA until 1980, he died in 1982, in Hawaii.

C. E. WYNN-WILLIAMS who had studied with Ernest Rutherford before his wartime work, returned to Imperial College London, where he became Reader in Physics. In 1957, he received the Physical Society's Duddell medal in recognition of his work on the counting device that would be used in Colossus. UK Government Scientific Intelligence advisor, Professor R. V. Jones, wrote in 1981: "The modern computer is only possible because of an invention made by a physicist, C. E. Wynn-Williams, which may prove to be one of the most influential of all inventions." He died in 1979.

MAX NEWMAN would go on to help produce the world's first stored-program electronic computer in 1948 in the Royal Society Computing Machine Laboratory at the University of Manchester. Known as the Manchester Baby, it was a direct ancestor of the Ferranti Mark 1, which in 1951 was the first commercially available general-purpose computer. It was co-developed by Conway Berners-Lee, father of World Wide Web inventor Tim Berners-Lee. Newman turned down an OBE in 1946, but was already a Fellow of the Royal Society before the war, and received its Sylvester Medal in 1958. He died in 1984.

ALAN TURING was famously persecuted by the British government for his homosexuality, taking his own life as a result, and eventually being pardoned in 2013. After the war, he worked for the National Physical Laboratory, where he developed ACE, the Automatic Computing Engine. Its 25 kilobytes of memory, accessed at a speed of 1MHz, was described as "very large indeed." He moved to the University of Manchester to join Newman, where he consulted on the software for the Ferranti Mark 1, before becoming interested in mathematical biology and morphogenesis, the development of patterns and shapes in biological organisms, before the structure and role of DNA were known. He was made an OBE in 1946, and a Fellow of the Royal Society in 1951. A road and bridge in Manchester are named for him, and there is a statue of him in the city, too. In 1999, Time magazine named Turing as one of the "100 Most Important People of the Century." He died in 1954.

GORDON WELCHMAN moved to the United States in 1948, where he taught the first computer programming course at the Massachusetts Institute of Technology. Among his students was Frank Heart, who would go on to help design the first routing computer for the ARPANET, the predecessor of the Internet. Welchman would work for Ferranti, and on secure communications systems for the US military at Mitre. He wrote a book about his wartime work in 1982, leading to him losing his security clearance and thus his position as a government consultant. He died in 1985.

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January 18, 1944, and attacked its first message on February 5. A Mark II machine, with 2,400 valves, became operational on June 1, just in time for D-Day, the Allied invasion of France, and would be joined by 11 more. The Mark II had 12 rings of thyratrons that simulated the 12 wheels of the Lorenz machine, and a six-character shift register of Flowers' design which, along with the five electronic counters, gave it five-way parallelism, so it was five times faster than the original and easier to operate. Its speed was still limited by the paper tape, but it meant the British were reading high-level Nazi communications, including those signed by Hitler, just hours after they were sent.

Colossus was built for one task, and so couldn't be called a general-purpose computer. Its programmability was limited, with the programs held in the positions of switches and jack panel connections, but its algorithms could cover five billion combinations of variables. Of course, the Germans hadn't sat still, and by August 1944, the wheel settings on all Lorenz machines were being changed daily, leading to a lot of work.

After the war, Colossus was a secret for 30 years. Units 1–10 were dismantled, their parts returned to the Post Office or Newman's Royal Society Computing Machine Laboratory at the University of Manchester. Flowers was ordered to burn all documentation. "That was a terrible mistake," he said later. "I was instructed to destroy all the records, which I did. I took all the drawings and the plans and all the information about Colossus on paper and put it in the boiler fire. And saw it burn."

Units 11 and 12 survived, however, and as the Government Code and Cipher School was renamed Government Communications Headquarters (GCHQ) and moved to a new building at Cheltenham, they, plus two replica Lorenz machines, were taken along. They remained there until 1960, used mainly for training and for checking that one-time pads (an unbreakable form of sending secret messages) were sufficiently random.

Those who knew about the machines, however, dispersed into academia and industry. The idea that high-speed digital computing was feasible and reliable was a powerful one, but it didn't catch on everywhere; when Flowers applied for a bank loan to build another machine, he was rejected because the idea was not considered likely to work. Constrained by the Official Secrets Act, he could not argue that he'd already built one. He remained at the Post Office Research Station, where he became head of the switching division, finally building his all-electric telephone exchange in 1950. He moved to Standard Telephones and Cables Ltd, and retired in 1969. He published a book on telephone exchanges in 1976, received an honorary doctorate in 1977, the Martlesham Medal in recognition of his achievements in computing in 1980, and in 1993 was awarded a college certificate, having completed a course in basic information processing on a PC. He died in 1998.

Recognition was not something the man who built the first computer sought in his lifetime, but it has come to him, slowly. There are at least two roads named for him, and a computing center for young people, The Tommy Flowers Centre, opened in 2010 near where he was born. At the R&D center operated by British Telecom (BT) – the successor to the Post Office in running Britain's phone network – a life-size bronze bust of Flowers was unveiled in 2013, and in 2016, BT opened the Tommy Flowers Institute, a training center for postgraduates moving into the telecommunications industry.

And despite the blueprints being destroyed, enough material survived in engineers' notebooks (a surprising amount of the material had made its way to the US) for a Colossus Mark II to be rebuilt between 1993 and 2008. The optical tape reader was rebuilt by its original designer, Dr. Arnold Lynch, and the working unit stands today in the position occupied by Colossus No. 9 at Bletchley Park, now The National Museum of Computing. It's the size of a bus, and makes a noise like the world's worst industrial metal band falling down the stairs.

A competition to celebrate the rebuilt Colossus pitted it against modern computers in receiving and decoding Lorenz messages. The winner, Joachim Schüth, using a 1.4GHz laptop and his own program written in Ada, took 46 seconds to find the settings for all 12 wheels. Colossus took three hours and 15 minutes. "My laptop digested ciphertext at a speed of 1.2 million characters per second, 240 times faster than Colossus," said Schüth at the time. "If you scale the CPU frequency by that factor, you get an equivalent clock of 5.8MHz for Colossus. That is a remarkable speed for a computer built in 1944." Remarkable indeed. Intel wouldn't get there for another 35 years. ■

Konrad Zuse

Working alone, with financial help from the government, German engineer Konrad Zuse produced the first programmable computer in... 1941? Zuse's work is often overlooked, but he began work in 1935 after becoming bored with the calculations he had to do by hand in his job at an aircraft factory. In 1936, he produced the Z1, a floating-point binary mechanical calculator with limited programmability, and also submitted some interesting patents. His work was destroyed in an air raid, but in 1939 he was called up for military service, and produced the Z2, an updated Z1 built with telephone relays.

While not a member of the Nazi Party, Zuse's work benefitted the regime and contributed to its missile programs. He was advised to work with vacuum tubes, but thought the idea "crazy." More bombing destroyed the Z3, a binary 22-bit floating-point calculator featuring programmability with loops, but the Z4 – a 32-bit floating-point programmable computer built from mechanical and electromechanical logic – was missed by the bombers.

Post-war, IBM took an option on his patents, providing an income, and by 1950 had delivered the Z4, the only working computer in continental Europe, to a Swiss university. The Z series would go up to Z43; the Z22 was the first computer to use magnetic storage. He submitted a PhD thesis to the University of Augsburg, but forgot to pay, so was rejected. He continued to work on programming languages, large format plotters, and even published a book on the digital structure of the universe. A painter in his spare time, Zuse died in 1995. The Zuse Institute for applied mathematics and computer science in Berlin is named in his honour.

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REACHING FOR THE STARS

A lot of the technology in your PC and your home originated in space, as Ian Evenden explains.

© STF/AFP via Getty Images

The Apollo missions used several technologies that have subsequently entered everyday terrestrial life.

That government-funded space agency NASA doesn't just strap people to the top of a firework and aim them at the Moon. It doesn't even do that now, but focuses on robotic science and exploration, and crewing the International Space Station.

This is an agency, after all, that has three probes currently on their way out of the solar system, including the fastest human vehicle ever launched. It has put robots on Mars and sent more to investigate Mercury and the outer planets. Its latest Martian rover is a nuclear-powered laser-armed tank with a helicopter strapped to it.

Along the way, you'd expect it to pick up some neat new technology – and it has. Some of it has become so everyday that we almost no longer think of it, and some of it is in your PC. So, from the essential to the futuristic to the urban myths, here are the NASA inventions that have helped humanity the most.

Portable computers

The guidance computers aboard space capsules were one thing, but it was only a matter of time before NASA wanted to take general-purpose computers into space. Beige boxes with CRT screens were too heavy and cumbersome to be shot into orbit aboard the Space Shuttle, so portable units were explored. This was the 1980s, though, and laptops were somewhat primitive.

In 1982, however, a company called GRiD developed the Compass, a computer that looks recognisably like a laptop. It was powered by an Intel 8086 CPU, with up to 512Kb of nonvolatile magnetic bubble memory (a defunct technology that was very durable, but tended to run a little hot), and things like disk drives available as peripherals. The casing was magnesium, and designed to act as a large heatsink for the CPU, memory, and the 320x240 plasma screen (which could be read in even the strongest sunlight, thanks to its bright orange text display). It came preloaded with office software, and cost the equivalent of $23,000 in today's money ($8,000 back in 1982).

NASA and the US military took no notice of the price tag, and enthusiastically embraced this little machine, blasting it into orbit in 1983 and sending it into combat with paratroopers. Competitors such as the Osborne 1 or the Compaq Portable used CRT displays, and couldn't match the Compass's toughness (one reportedly survived the tragic 1986 Challenger disaster). NASA's only modifications to the hardware were a new cord to match the Shuttle's power system, bits of Velcro to hold it in place, and a fan to aid in cooling, as convection is tricky in space. On the software side, however, the newly rechristened SPOC (Shuttle Portable On-board Computer) received special graphical software to display the orbiter's position relative to Earth, and a backup copy of the re-entry program, just in case.

Thanks to its eye-watering price, the Compass became a symbol for affluence in many movies – you can see one in *Aliens*, *Wall Street*, and *Pulp Fiction*. If you want to see one today, go to the National Air and Space Museum in DC. As the first recognisable modern laptop, however, its influence is stronger than even its magnesium shell – the clamshell design, the flat screen, the storage with no moving parts, which is surely the precursor of today's SSDs.

Today, the Lenovo Thinkpad is the only certified computer for use on the US side of the ISS. There are over 80 of them up there, and they run Debian Linux. Some are connected to the ISS main computer as remote terminals for interacting with specific pieces of hardware.

The Russians use Linux, too, although the specs of their systems are more mysterious, and are just referred to as "Russian Laptops."

Switched-mode power supply

The Apollo Guidance Computer is often held up as an example of how to do a great deal with very few resources. Running at about 2MHz, it had enough RAM to store 2,048 16-bit "words" and weighed 31kg. That, plus Isaac Newton and a few digits of pi, is all you need to fly three men into lunar orbit. What's equally interesting, however, is the way it was powered – the switched-mode power supply is the same type that provides the juice to your PC.

While earlier Gemini craft had been flown manually, Apollo capsules were computer-controlled, except during landing. Each mission to the Moon carried two guidance computers – one in the command module and another in the lunar lander (except for Apollo 8, which didn't land), with further computers on the Saturn V rocket and in the launch abort system.

The guidance computers were built by MIT using some new technology – the "integrated circuit" made of silicon – and there was some debate over whether it would work, with a backup IBM system also built. The MIT system was triply redundant, and never experienced a hardware failure.

But back to its power supply. The MOSFET (metal oxide semiconductor field-effect transistor), invented at Bell Labs in 1959, became the most popular way of power switching, in which output voltage and current can be changed by switching elements between different configurations inside the PSU. The advantage of this is greater efficiency, smaller size, lower weight, lower noise, and the use of a wider range of voltages and power frequencies than a linear regulator.

Switched-mode power supplies are everywhere now, from your PC to your cell phone charger, often with universal inputs so they can accept power inputs from around the world. The ATX standard offers 3.3V, 5V, and 12V rails, with a typical power output of over 500W, compared to the Apollo Guidance Computer's 4V (CPU) and 14V (memory and interface) at 55W.

If it can power a computer that can guide a space rocket, it can sure as heck power your PC.

Astronaut John O. Creighton poses with onboard GRiD Compass computer, displaying a likeness of *Star Trek*'s Mr. Spock, aboard Space Shuttle Discovery mission STS-51-G on June 18, 1985.

Neil Armstrong, first man on the Moon, wearing an early Plantronics headset.

Wireless headsets

What links Neil Armstrong as he stepped on the Moon with Boeing 747 pilots and every call-center worker ever? They all wear the same headset. It's barely changed in 50 years, and was originally designed to be implanted in an astronaut's helmet.

Pilots at the time wore bulky headsets, and in 1961, United Airlines invited proposals for an improved design. One pilot, Courtney Graham, teamed up with his friend Keith Larkin to create a new headset using transducers – a common hearing aid part that's also used in magnetic tape heads and electric guitar pickups.

Once their design had been accepted by United, Graham and Larking opened their own company – Pacific Plantronics – and set to work producing headsets for pilots and, a year later, air traffic controllers. Everyone, it turned out, wanted a better headset, and Plantronics was contracted by NASA to create something for the Mercury spacecraft. It took 11 days to put together a working headset design for space communications that also incorporated noise-canceling, and astronaut Wally Schirra was the first to use it on the Mercury-Atlas 8 mission, which orbited the Earth six times in 1962. The system would go on to be used in the Apollo Moon landings, and on to this day, while Plantronics now employs almost 4,000 people and has assets of over three billion dollars.

Memory foam

If you've got a gaming chair, a wrist rest, a headset, or even a bed, you're probably familiar with memory foam. Also known as temper foam, it comes from a NASA contract in the 1970s aimed at improving seat cushioning under astronauts when they were being subjected to high G-forces. It also meant that seats no longer had to be customised for every astronaut's body shape.

The mouse

NASA can't quite take full responsibility for the ubiquitous pointing devices – they date back to the late 1940s, and a British Navy fire control radar system that tracked incoming aircraft and calculated where to put missiles to best inconvenience them. The British classified it a state secret, but you can't keep a good concept down, and in the 1960s NASA was looking for new ways to interact with data on computer screens. Doug Engelbart, from the Stanford Research Institute, California, was busy inventing what we now call a GUI (graphical user interface) – computers with bitmapped screens, hypertext, collaborative tools, and pointing devices.

NASA was interested in the same things, and granted Engelbart funding to find the best pointer. The early mouse was a wooden device with two wheels underneath at 90 degrees to one another, and a rocking mechanism enabling you to draw straight lines. It was designed by Engelbart's lead engineer Bill English, and patented by Stanford in 1970 as an "X-Y Position Indicator For A Display System." The name "mouse" came about because of the cable, which looked like a tail, with the on-screen cursor known as a "bug," which didn't catch on.

"We were looking for the best – the most efficient – device," Engelbart said. "With NASA funding, the team developed a set of simple tasks, and timed a group of volunteers in doing those tasks with various devices. The mouse out-performed all the others. Devices like the light pen simply took too much time, by repeatedly requiring the user to pick up the pointer, and reach all the way to the screen."

Engelbart received no royalties, and Stanford licensed the tech to Apple for $40,000. The only problem NASA had with the mouse, according to Engelbart, was its tendency to float away in zero gravity.

Engelbart and English's first computer mouse prototype.

© nasa, SRI International/Wikimedia

Camera sensors

Tiny cameras – in cell phones, webcams, GoPros and the like – have developed from NASA efforts to create compact, low-cost imaging systems.

The first type of digital imaging sensor was the CCD, or charge-coupled device. This operates in lines, with the data being passed from pixel to pixel until it reaches the edge of the chip, where it can be amplified and recorded. By replacing the CCD with a new sensor based on CMOS (complementary metal-oxide-semiconductor – the same tech in motherboard CMOS memory), every pixel can amplify its own charge, making the sensor more energy-efficient and sensitive. This is an active-pixel sensor (APS), and was first developed at Olympus in Japan, with Toshiba and Canon following. CCDs remained dominant, however.

NASA's Jet Propulsion Laboratory was able to make the first APS outside of Japan, with a team led by Eric Fossum. He left to found Photobit with his partner, Sabrina Kemeny, in 1995. It commercialised the APS tech, pushing it into areas such as endoscopy, DSLR cameras, cell phones and webcams. Photobit sensors appeared in Logitech and Intel products before the company was bought by Micron in 2001. With the arrival of HD video, most camera manufacturers switched to CMOS technology, as its low power consumption meant more pixels could be integrated without overheating or draining the batteries.

While CCDs are still used in astronomical imaging (in the Hubble Space Telescope, for example), new CMOS chips could chase them off completely. With high resolutions and low read noise, they're ideal for capturing faint, distant galaxies.

MRI and CAT scans

The digital signal processing tech developed by NASA to enhance pictures of the Moon in the Apollo program is used in MRIs and CAT scans. It also lives on in ACTIS, the Advanced Computed Tomography Inspection System, which produces scans of rocket engines or metal castings to identify flaws. It has also been used to examine T-rex fossils without removing them from the rock they're embedded in.

Mylar

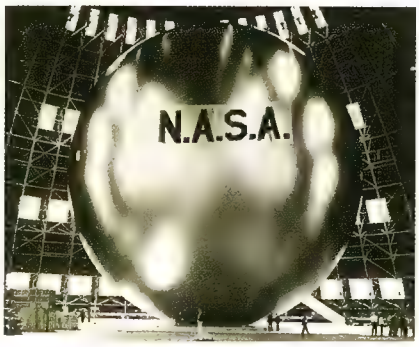
Coat some plastic film (biaxially-oriented polyethylene terephthalate, to be precise) with a thin layer of aluminum, gold, or another metal, and you've got Mylar, a thin sheet that reflects 99 percent of light, including much of the infrared part of the spectrum. Add another layer of polyethylene, and you've got something that's puncture-resistant and impermeable to gases.

Its uses are myriad. It's in speakers, headphones, and mics. It's in keyboards. It's in floppy disks and cassettes, if you've got any hanging around. From pinball machines to the capacitors on your motherboard to the silver blankets emergency services use, it's there. If you play banjo, it's there, too.

You'll also know it as the silver coating of the descent stage of the Apollo lunar module, or the wrapping for the Hubble Space Telescope. Its ability to insulate while being thin and light makes it ideal for spacecraft, which is why NASA developed it.

Actually, its history goes back to the chemical companies DuPont, ICI, and Hoechst in the 1950s. They developed the BoPET film, and Kodak went on to use it as a backing for the 6,000-feet reels of film used on long-range U2 reconnaissance flights. NASA's input was the metallic coating – in 1960, it launched Project Echo, a passive communications satellite that was really a large balloon. The Mylar spheres left the atmosphere on top of a rocket, then inflated to 100 feet in diameter. They were passive, serving only to reflect the microwave transmissions beamed at them.

There was one problem with them. Because they were large and light, they were pushed by the solar wind,



Echo 2 undergoes a stress test in a dirigible hangar, North Carolina, 1964.

something NASA has been keen to take advantage of with its experimental technology demonstrator Sunjammer. Other space agencies are in on the idea, too, such as Japan with IKAROS: Huge sheets of Mylar that use the stream of energised particles expelled from the Sun as a means of propulsion.

Dealing with dust will be a major problem when humanity goes back to the Moon.

Dustbuster

Every time you suck the dust out of your PC's case with a handheld vacuum cleaner, you're following in the footsteps of astronauts who collected samples from the Moon.

It all comes down to a cordless power drill designed for use on the Moon, which had to be able to drill into rocks yet consume the smallest amount of power possible. While most of the samples collected by astronauts were picked up from the surface, subsurface soil was also dug up from depths of up to 10 feet. As they didn't want to carry huge numbers of batteries around with them, the drills needed their own power source, and to be as small, light, and powerful as possible.

Black and Decker worked with NASA on the problem, eventually coming up with a computer program that optimized the design of a magnetized motor for minimal power consumption. All the R&D carried out was folded back into Black and Decker's product line, resulting in a range of cordless appliances, and leading to the launch of the Dustbuster in 1979. It sold a million in its first year, and more than 100 million since then.

Dust is a problem in space, so the tech came full circle when NASA put out a call to universities in 2019 asking for ideas for keeping abrasive Moon dust off surfaces and spacesuits. A team from the University of Colorado Boulder came up with a negatively charged electron beam which, when applied to dust in a vacuum, causes it to leap away from the surface it's sticking to. So, in 20 years, we'll be cleaning our PCs with electron beams.

Astronaut Chris Cassidy wears a VR visor, gloves, and vest to test Robonaut 2.

Inset below: The AERCam Sprint emerges from the cargo bay of the Space Shuttle Columbia, 1997.

Virtual reality

The 1980s were a good time for virtual reality. There was investment from games companies and the military, and a dream of a space station with a virtual environment, in which astronauts lay on couches and used VR to control robots to do all the work.

This didn't happen. The ISS isn't a gleaming white sci-fi utopia, but a cramped and occasionally leaky conglomeration of modules, nationalities, and technologies. The tech of the 1980s proved to be unsuited to the task – the helmets were too heavy, early touch interfaces didn't work, and computers were too slow to create what was needed.

Following a re-think, equipment such as the AERCam Sprint – a free-flying camera powered by nitrogen thrusters and enough battery for seven hours' flight – were steered using laptop screens rather than through a VR headset, but NASA's attempts to create a robot to work alongside astronauts have seen it collaborating with Sony. PlayStation VR was the platform for Mighty Morphenaut, a training game designed to help humans operate the Robonaut 2 robots, which look like a terrifying amalgam of Bishop from *Aliens* and a Cylon.

There have been teething problems, however, especially due to lag. "The hope is that by putting people in an environment where they can look around and move in ways that are much more intuitive than with a mouse and keyboard, it would require less training to understand how to operate the robot and enable quicker, more direct control of the motion," said Garrett Johnson, a software engineer at NASA's JPL, in a 2016 interview. "[With Mighty Morphenaut] we were able to explore a possible solution and … demonstrate the problems of operating with delayed communication. With time delay, anticipating the motion of a floating object makes it nearly impossible to interact, so further research might include ways to help users predict that kind of motion." ■

© NASA

Scratch-resistant lenses

If your glasses or shades boast that they're scratch resistant, they probably have a NASA invention sprayed on them – a layer of diamond-like carbon that protects plastic lenses from scratches and also reduces friction, so water runs off them easily. It was originally developed to coat the visors of space helmets, and both the coating and the method of depositing it are NASA tech.

Invisible braces

If you've had teeth straightened using invisible braces, you've been wearing a NASA-developed ceramic originally made to help track missiles. Transparent polycrystalline alumina is stronger than steel, and was used to make the domes that cover radar installations. It's not the first time space tech has made its way into our mouths – some fillings use material developed for the heat-resistant tiles on the Shuttle.

THE NO COST PC TOOLKIT

The best of the freebies

50 completely free programs you should install on your PC, with **Sam Lewis.**

We're not saying you should install all 50 of these programs at once, but these are our recommendations for software that we feel will hopefully benefit you in some way, give you a good experience, or simply add a little entertainment to your day. And who doesn't like a freebie?

Paying for things can get tiresome, not to mention expensive, but thankfully there are plenty of free alternatives or routes to take instead of delving deep into your pockets to buy an application. We've rounded up a wide range of programs here that enable you to improve your PC's efficiency, customise your rig, get creative, or just have some fun.

The free market has rapidly changed over the last decade. Cell phones have played a huge role in this transformation, because we've grown to expect more and more from free services. The quality of free applications available now compared to even a just few years ago has shifted massively. For instance, triple-A title *Call of Duty* is now offering a fully immersive and epic gaming experience with its battle royale game mode, "Warzone," taken from *Modern Warfare* – all for free. Of course, it's a clever way to entice you into the franchise, but the free gaming market has exploded because of titles like this. It sets a bar, with high expectations for the quality of free applications and games to continue upward. The free market is an exciting area to keep your eye on, so here's 50 of the best programs that won't cost you a cent.

Maintenance & repair

01 TechPowerUp GPU-Z

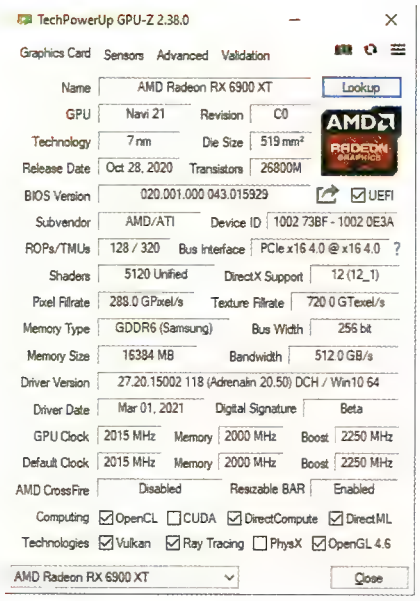
GPU-Z is a lightweight program that tells you everything you need to know about your graphics card. It's a quick, effortless solution to keeping tabs on lots of data in one place. You can check the GPU's BIOS version, when the card was released, the GPU clocks, and so on. Other metrics revealed by the software include temperature, core frequency, memory frequency, GPU load, and fan speed tracking. Who wouldn't want this data for free, and always just a few clicks away? **www.techpowerup.com**

02 CPUID HWMonitor

As the name suggests, HWMonitor is a hardware monitor, and focuses on the health of your PC. The application enables you to take a look at the main health sensors, such as voltage, temperature, fan speed, and so on. It's a great place to check whether anything is a particular bottleneck if you're experiencing performance problems. It can help you identify why these issues are occurring, and confirm whether they're hardware-related. It's a free, easy-to-use PC doctor, and a big part of our testing suite here at the magazine, too. **www.cpuid.com**

03 CCleaner

The more you use your PC, the more it becomes cluttered with unused files, settings, and junk, which all combine to slow down your once beautifully fluid machine. Obviously, this is far from ideal, but CCleaner is specifically designed to fight against the problem. It features a file cleaner to eliminate all the pesky excess for increased speed, a privacy protection tool to remove tracking and browsing data, and a health check to automatically analyze, fix, and tune your PC's performance. **www.ccleaner.com**



Get the complete skinny on your graphics card with GPU-Z.

04 CPU-Z

Here's a handy tool to reveal extra information about your CPU that Windows usually likes to keep hidden away. CPU-Z can tell you which processor you have, what chipset it uses, which motherboard is installed, and information about your memory, all in an easy-to-use lightweight application. It can be particularly useful for overclockers – even though it isn't specifically filled with overclocking features, it can help you create a report about your system's hardware specifications, which you can then use alongside HWMonitor. **www.cpuid.com**

05 WinDirStat

If your PC is ever tight for space, WinDirStat can give you a helping hand with the matter. It's always a pain in the backside to figure out what's clogging up your PC's storage, but with this application, you get a visual report so you can literally see what's taking up all the room. Simply put, it is a disk usage statistics viewer and cleanup tool, which displays your storage as colourful visual tiles, so you can see where all your space has gone. **https://windirstat.net**

06 Cinebench

Benchmarking is a great way to compare your rig against another PC's performance. The results can determine what you are able to get out of your PC and which elements are having the most impact on a game's frame rates, for instance. Cinebench is a visual benchmarking tool and the built-in leaderboards make it really easy to compare your results. It will give you an idea of whether your CPU is performing adequately compared to similar CPUs, and can give you an indication of how much of an

Visualising storage with WinDirStat makes storage management a walk in the park.

improvement to performance a newer processor could add to your system. **www.microsoft.com**

07 CrystalDiskMark

An open-source hard drive benchmarking tool, CrystalDiskMark is used to determine the read and write speeds of your SSD. It measures these speeds in sequential and random positions, with varying numbers of queues and threads. Like all benchmarks, you can use the data generated to compare your machine against other PCs to ensure yours is running up to speed, and that all your drives are operating correctly. **https://crystalmark.info**

08 Recuva

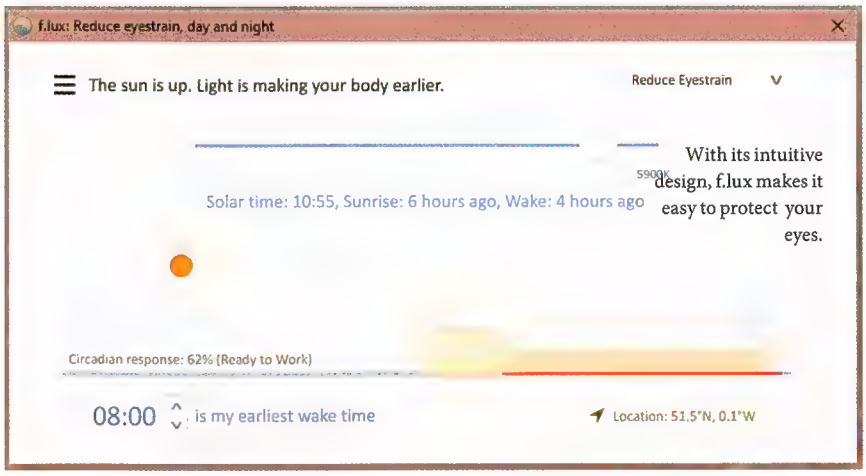
Deleting the wrong file can give anybody a fright, but what if you do that and then proceed to delete it from the recycling bin, too? First of all: unlucky. Secondly, don't fret, because Recuva can help recover deleted files for you. When you delete a file on your thumb drive, hard drive, or SSD, the file isn't necessarily gone instantly. The block of space that the files were taking up has merely been relabeled as "free space" so it can eventually be used to store something else. Recuva can look to see if it's there, but the longer you leave it, the more likely it is that the file will have gone, so as soon as you accidentally delete something, find it on Recuva ASAP! **www.ccleaner.com**

09 MediaInfo

Like a lot of these programs, the name kind of gives it away. If you need to find out information about a media file, MediaInfo will do just that. Right-click a video, for instance, and then click MediaInfo, and you can find its technical details all in one place. You can learn about the codec, video bitrate, audio stream, resolution, and FPS, for example. It's a good method of checking whether a video you've rendered has been saved to the correct format. **https://mediaarea.net/en/MediaInfo**

10 FurMark

With its OpenGL routine, FurMark will put your GPU through its paces. The aim is to see how your GPU withstands its strenuous benchmarking test, to compare it against others. FurMark is no laughing matter, though, as it's been known to damage PCs, so take it steady, and make sure your cooling is up to scratch. The website gallery even shows hardware that has been defeated by this app, so make sure you know what you are doing. On the plus side, at least you don't have to pay for it. **http://geeks3d.com/furmark**



With its intuitive design, f.lux makes it easy to protect your eyes.

Customisation & efficiency

11 QTTabBar

A feature that should already be integrated into Windows Explorer is the use of tabs. Every time you open Windows Explorer, another window opens, and before you know it, your PC is flooded with pesky pop-ups. QTTabBar adds tabs to Windows Explorer, just like you see in a web browser, making file searching and transferring a much more fluid experience. Head to the "View" button in the taskbar, then to the "Options" drop-down, and click "QTTabBar" to enable it. Now just right-click a folder to open it in a new tab. It still looks and feels the same, but with the added benefit of tabs. **http://qttabbar.wikidot.com**

12 f.lux

Blue light isn't great for your eyes, and using any sort of screen later on in the day or through the night can cause eye strain, which can massively impact your productivity, procrastination, gaming, or whatever else you are getting up to. What f.lux does is change the colour temperature of your screen to match the time of day. This, in theory, should cause less eye strain, resulting in fewer headaches and a better night's sleep. And, of course, it's free, so it gets two thumbs up from us! **https://justgetflux.com**

13 Rainmeter

An all-arounder for great visual PC customisation. You can add skins to your desktop to make your computer your own and personalise it to your heart's content. Rainmeter is full of widgets to add to the desktop that give you advantages over the standard theme. You can add hardware-monitoring widgets to always keep an eye on your PC's performance, or add clocks, calendars, audio visualisers, and more. If you like making things your own and want to experiment with desktop customisation, Rainmeter is a great shout. **www.rainmeter.net**

14 Fences

This one certainly sits on the fence between customisation and efficiency.... Ouch, that was painful – sorry! Anyway, Fences is a neat little piece of software that organises your desktop icons and shortcuts into folders, much like those on your phone's home screen. Unfortunately, the latest version requires a few bucks, but you can go ahead and download an older version of the software for free or try the 30-day free trial option. **www.oldversion.com/windows/fences-1-0-1**

15 Folder Marker

If you struggle with organising your folders, this is another tool that can help you with getting everything sorted. It enables you to change icons and add color to your Windows folders. When working on large projects that use a load of different folders, it can be a pain navigating your way through the mess. Now you can right-click a folder, click "Folder Marker," then change the priority status or work type of the folder to make everything clear and tidy. It's a small program but it can really help with work efficiency. **https://foldermarker.com/en/folder-marker-free/**

16 EarTrumpet

With a funky name like that, it's a shame the app isn't quite as exciting as its moniker implies, but it's a nifty and clever addition to your setup nonetheless. EarTrumpet is a sound icon that sits in the taskbar, but as it looks similar to the existing one, it's best to

remove that first. What this app does over the standard sound control is change the volume of different sound sources. You can already do this if you're prepared to route around in the settings, but it's so much easier with EarTrumpet. **www.microsoft.com**

17 ShareX

There are plenty of screen-capturing programs available, but ShareX is a particularly feature-packed example. It can capture screenshots and record with several options for how you want to capture, including full-screen, active window, active monitor, window menu, monitor menu, screen recording (GIF), scrolling capture, and webpage capture. This app makes it super easy to capture what you need, especially when paired with the provided shortcuts that you can find in the hotkey settings. **www.microsoft.com**

18 Everything

Windows search is definitely an essential part of the operating system, but sometimes it can be painfully slow, and isn't always the easiest solution for finding exactly what you need on your PC. With Everything, it is very easy to find what you are looking for, making the whole process so much quicker. Another simple yet effective alternative to improve your overall PC experience. **www.voidtools.com**

19 MyFolders

This effective tool adds a context menu that enables you to access your favorite folders from any right-click. Using MyFolders' interface, you can add your folders while organising their location. Once activated, and with your selected folders added, you can now right-click anywhere, click "MyFolders," then "Go to," and you will find your selected folders available from the menu. A quick and easy to find what you need. **www.coretechnologies.com/products/MyFolders/**

20 7 + Taskbar Tweaker

This taskbar customisation tool falls right in the line of sight of people who like to have tight control over how their PC's interface looks and behaves. It makes your taskbar more interactive, giving you options to change the function of current buttons, alter how mouse buttons interact with the taskbar, change thumbnail previews, add functions to empty space, and much more. Add this free piece of software to interact with your PC exactly how you want. **https://rammichael.com/7-taskbar-tweaker**

Gamer's toolbox

21 Razer Cortex

If you want an extra boost that focuses your PC's power on the things that really matter, look no further. Use Razer's suite of gaming optimisation tools to achieve higher frame rates and loading times. It also features a system booster that automatically detects and deletes junk files to free up space, similar to CCleaner. A great addition to help your gaming experience. **www.razer.com/cortex**

22 LaunchBox

If you enjoy dabbling with emulators, LaunchBox is an excellent launcher to store and display your retro collection all in one place. Its crowd-sourced library organises everything, and the visuals on this launcher are, quite frankly, stunning. Including instruction manuals for the emulators, it's a super-friendly and easy-to-use package. Even if you aren't into emulators, it can store your Steam library, too. **www.launchbox-app.com**

EarTrumpet's simplicity is what makes it so easy to quickly adjust your sound outputs.

23 Pin Steam

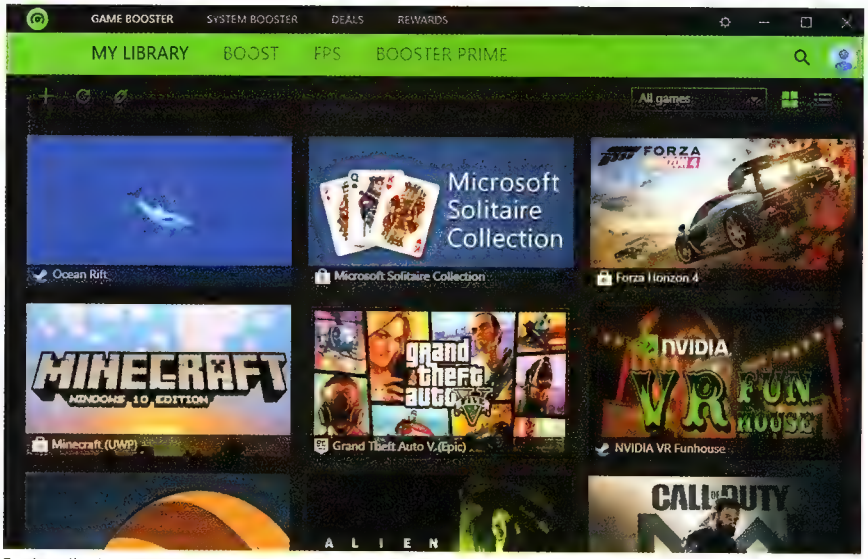
Everyone wants to make their PC aesthetically pleasing and effective, right? Well, here's one for your Steam games. As the name suggests, it enables you to pin your Steam titles to your Start menu with cool-looking tiles. Compared to standard icons, these visually rich tiles add detailed artwork to your Start menu, making it much easier to find and organise your games while improving the look of your PC. **www.microsoft.com**

24 Discord

You have to be living under a rock if you haven't heard of Discord; this free communication app was bound to feature on our list. Although it has all sorts of uses, it can facilitate any sort of online chat, from VoIP to text to video, making it essential for gamers who want to hang out online with their pals. Its simplicity makes it a breeze to use, and for gamers, communication is key, so install this if you haven't already. **www.discord.com**

25 GeForce Experience

Calling all Nvidia GeForce GTX users: You need this app. This free software is a great graphics card manager. It keeps your drivers up to date and optimises game settings for better performance. You can also use GeForce Experience to share exciting in-game moments with pals. **www.nvidia.com**



Cortex displays your library with large artwork, for a simple yet effective UI.

26 MSI Afterburner

Designed to push your Nvidia or AMD graphics card to the limit, MSI's Afterburner is a great tool for overclockers as it focuses on clock speed and video memory, enabling you to get better frame rates by increasing voltages and clock speeds, unlocking your GPU's potential. Make sure you have more than adequate cooling, though; the last thing you want is a fried GPU for breakfast, especially in this climate. **www.msi.com**

27 SuperF4

We all know the pain of being stuck in a game when everything seems to crawl up and die. Your game freezes and you're forced to quit. Alt-F4 should do the trick, but this isn't always the case; Windows only asks the program to quit, and lets it decide for itself what to do. SuperF4, however, kills the foreground program when you press Ctrl-Alt-F4, or you can press Win-F4, then click the window with your mouse cursor. Straightforward but essential for those infuriating times when your PC just doesn't listen.
https://stefansundin.github.io/superf4/

28 GameSave Manager

As the name suggests, GameSave Manager's purpose is pretty simple: It enables you to automatically back up all your game save files at once and restore them. It also offers scheduled backups, and can tie in with cloud services such as Dropbox. If you're paranoid about game saves vanishing into thin air, GameSave Manager could be your golden ticket out of the missing or corrupt file abyss.
www.gamesave-manager.com

Essential free games

29 Call of Duty: Warzone

We mentioned it in the intro, so there's no shock that it features in our list. The bottom line here is that you get the same *Call of Duty* quality we all know and love, but for free. Of course, you only get the battle royale mode, not the campaign or standard online features, but battle royales are taking over, and the *COD* franchise sure knows a thing or two about producing a solid visually brilliant first-person shooter. Put two and two together and you have a great free game.
www.callofduty.com/warzone

30 Counter-Strike: Global Offensive

CS: GO has been popular for years, and by the looks of things, it's not going anywhere soon. At some point, you're bound to have played or watched it, and now it's free on Steam. For the uninitiated, it's an online team-based shooter; if you want to play casually with friends, you can, if you want a high-intensity competitive experience, you can have that, too. *CS: GO* works across all sorts of performance levels, so is a very accessible PC game.
http://store.steampowered.com

31 Old School RuneScape

If you love *RuneScape* and need to fill the nostalgia void, *Old School RuneScape* should do the trick. After a poll to revive it received over 50,000 votes, a separate older version of the already massive *RuneScape* was released in February 2013 to subscribers. By 2015, it was free to the public. It's one of the best retro MMORPGs to date – check it out now.
https://oldschool.runescape.com

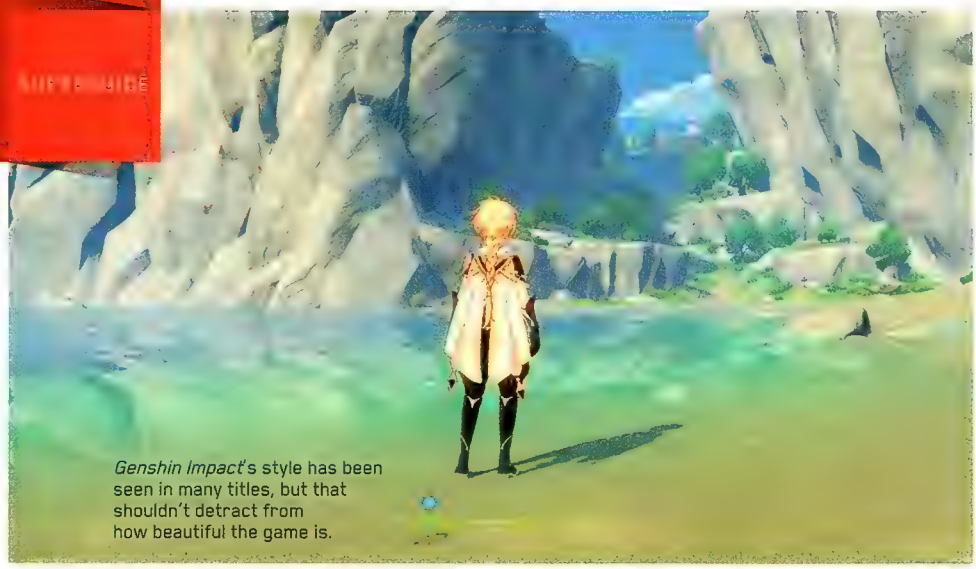
32 Fortnite

Although you might be sick to death of this game, you can't deny its mass popularity, competitive nature, and attractive bright art style. It's certainly not going away anytime soon, and it continues to bring huge amounts of traction to gaming. Its building capability, paired with shooting and bringing the battle royale game mode to the forefront, are what sets this game apart, and why it continues to be one of the best free games on the market. If you want to hop online with your buddies, it's a great place to have a laugh, but also somewhere you can get carried away in its intense competitive underside, too.
www.epicgames.com

33 War Thunder

War Thunder was first announced back in 2011, with its worldwide release falling in 2013, and since then it has been one of the most prominent vehicular combat multiplayer games available. Its main focus is on richly detailed aviation battles, with over 1,900 aircraft, ground vehicles, and warships to immerse yourself in. The graphics are stunning when running on full settings, and you can't ask for more when it comes to a completely free MMO.
http://store.steampowered.com

Take control of your graphics card with MSI Afterburner – just don't grill it.



Genshin Impact's style has been seen in many titles, but that shouldn't detract from how beautiful the game is.

34 DOTA 2

A top-down arena battle game that's almost certainly one of the best-known MOBA games to date, *DOTA 2* essentially spawned from a mod for *Warhammer III: Reign of Chaos*, but it's made a name for itself, especially in the esports scene. It was developed by Valve, with major involvement from the original creator of *DOTA*. If you're into real-time strategy and tower defense games, this MOBA is a brilliant free addition to your arsenal. **http://store.steampowered.com**

35 Destiny 2

Closely following the construction of an open-world game, you can wander freely around this gorgeous game, either to explore every nook of the map or find quests to complete the campaign. The mythical sci-fi-inspired world is captivating, with its shared-world-style multiplayer. There are elements of PvE and PvP throughout, and with a triple-A FPS RPG like this costing nothing, it's worth giving it a go. **http://store.steampowered.com**

36 RaceRoom Racing Experience

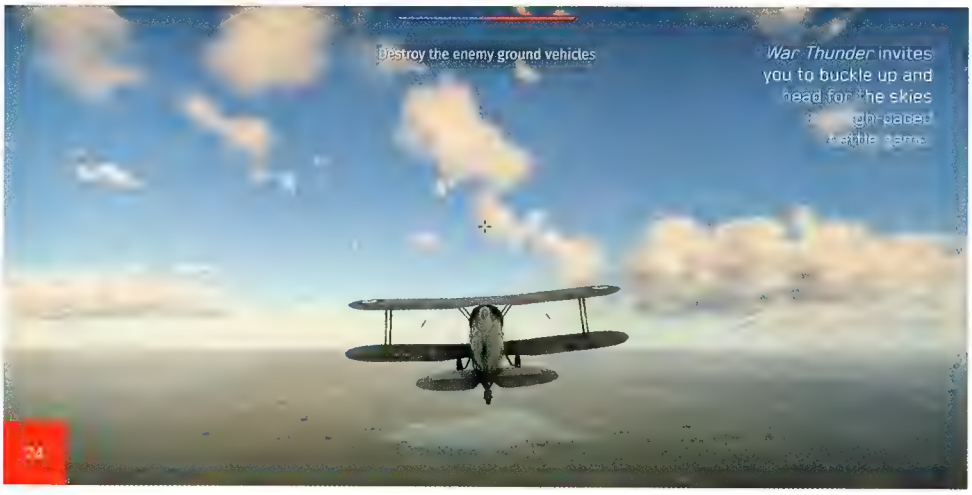
RaceRoom is one of our favorite car simulators. Its addictive yet realistic gameplay is a great example of what you can get from a free game. It's not quite full-fledged, like the paid alternatives, but the visuals are still stunning. *RaceRoom* is home to official race series such as DTM, WTCR, the WTCC, and ADAC GT Masters. If you want to race like a professional, jump into the driver's seat right here. **http://store.steampowered.com**

37 The House in the Woods

Why not throw a horror title into the mix? If you've seen *The Blair Witch Project* and weren't scared enough (props to you), try out this game, then see how you feel. The story sees you out on a camping trip in the deep forest, when your friend vanishes during the night. You step away to investigate, but then you get lost, too. Classic scenario, but you'll certainly get the chills here. Whether you want to freak out your pals or enjoy the adrenaline that horror games give you, *The House in the Woods* is sure to satisfy. **www.itch.io**

38 Genshin Impact

What you get here is a stunning open-world experience that uses elemental magic, character switching, and great brawls to draw you in. Visually, this fantasy adventure draws inspiration from the likes of *Breath of the Wild*, but we view that as nothing but a positive. There are tons of resources to collect, craft, and cook with, plus mini-bosses to fight and puzzles to complete, so *Genshin Impact* will still keep you on your toes even when you aren't following the campaign mode. **https://genshin.mihoyo.com/en**



War Thunder invites you to buckle up and head for the skies in high-paced battle game

Creativity & productivity

39 Adobe Photoshop Express

The Express edition of Adobe's world-famous photo-editing software is a free-to-use lightweight version. If you don't need the full version of Photoshop or don't want to pay the monthly fees (like many of us), this offers the same Adobe quality in a smaller package. It gives you all the basic features you need to edit pictures quickly. **www.microsoft.com**

40 Blender

Fancy making 3D models for free? Then Blender has got you covered. With this incredible software, you can design and make models using a wide range of available tools. You can then go on to animate and motion-track the models you've created. The only real limit is your imagination. It can even act as a video editor or a 2D animation suite – combined with its amazing rendering engine, it all makes for a fabulous free tool. **www.blender.org**

41 DaVinci Resolve 17

For a while, this program has been one of the best color graders on the market, but it's now a full-fledged video editing suite, too. It's been used for many large commercial projects, and you can check them out for yourself on the DaVinci website. If you are just beginning to dip your toe into video editing, or perhaps you already use other programs, such as Adobe's Premiere Pro or Sony Vegas, we recommend you take it for a spin – it's free, after all. **www.blackmagicdesign.com**

42 LibreOffice

If you only use the basic features of Microsoft Office, LibreOffice is a great alternative that checks most of the boxes, but without the associated price tag. It's certainly not as feature-rich as Microsoft's flagship, but for creating most day-to-day documents, this suite should be able to produce what you need. It has alternatives for Word, Excel, PowerPoint, and more – not bad. **www.libreoffice.org**

43 HandBrake

A little different from your traditional hand-operated stopping device, HandBrake is an open-source, free-to-use video converter. It's a must-have for video editors, because it's both powerful and easy to use.

HandBrake converts video files into different formats, can be used for opening files of a random codec, or to make files more universally accessible. Free, easy, and obscurely named, we love it. It's also a handy benchmark tool, too. **www.handbrake.fr**

44 Audacity

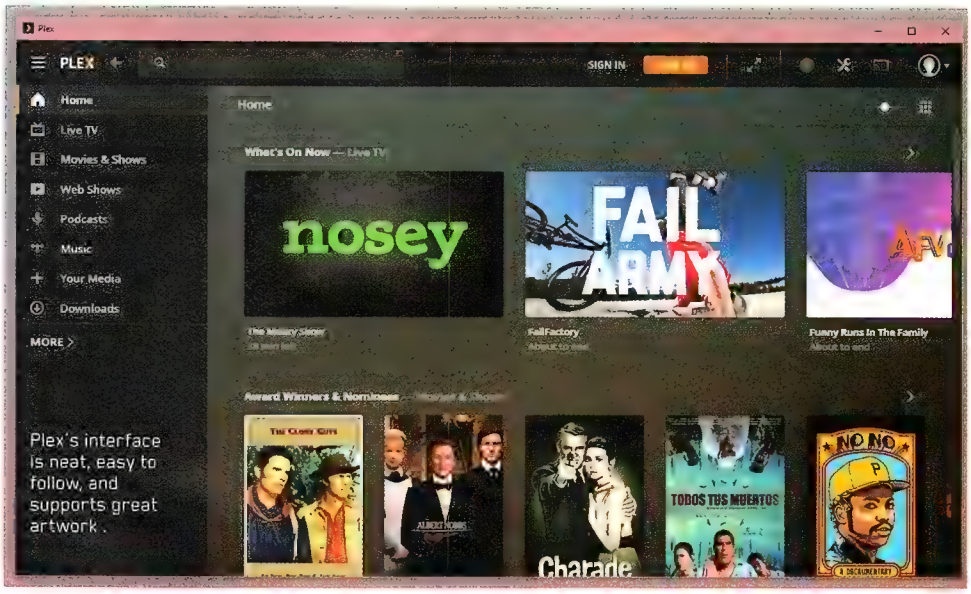
If you need to record your voice, whether that be from voiceover dubs, voice memos, video recording, or even if you want to kickstart a career in opera, Audacity is a superb free audio recording program. You can record, trim, add effects, re-organise, fade in and out, and much more. For audiophiles and microphone fanatics, this is an excellent choice, and a perfect alternative to Adobe Audition, albeit a little slimmed down. **www.audacityteam.org**

45 Fresh Paint

Microsoft's Fresh Paint gives you a canvas on which to unleash your inner Picasso – well, you can attempt to, at least. It's a painting app with plenty of great tools for all sorts of artists. You can even transform pictures into paintings. It's the type of program where you can dabble a bit when the creative urge takes you, or spend hours using it to create a masterpiece. **www.microsoft.com**

46 GIMP

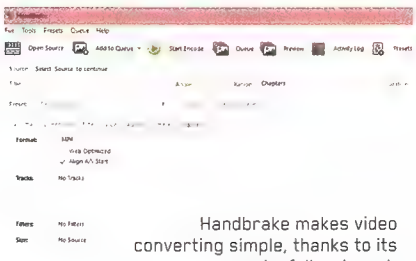
This community-driven and developed image editor was bound to make an appearance here. Although it will never reach the same heights as its heavyweight rival Adobe Photoshop, GIMP has a strong foothold in the photo manipulation market, and its free price tag has a big role to play in that. It provides you with the right tools to get the job done, whether that be for graphic design, illustration, photography, or just messing around. **www.gimp.org**



Plex's interface is neat, easy to follow, and supports great artwork.

47 FocusWriter

One of the biggest issues faced when trying to get a new writing project of the ground is the distractions that come along when working on your PC. We can definitely vouch for this one. FocusWriter helps you to stay in the zone with your writing by eliminating all these distractions. Its writing environment is light, distraction-free, and simple. It utilises a hideaway interface that you access by moving your mouse to the edge of the screen. It's very basic, but definitely gets the job done. **https://gottcode.org/focuswriter/**



Handbrake makes video converting simple, thanks to its easy-to-follow layout.

At first glance, Blender can look a little confusing, but with a little practice and patience, you'll realise how many incredible features this free software offers.

Entertainment

48 Plex

A great hub for all of your downloaded video files. If you have a massive database full of (legally owned) TV shows, movies, and documentaries, you can store them all in Plex. It's a media server that enables you to stream your files to your other devices. The interface is very tidy and designed to work effectively, organising your files with the appropriate artwork. You can find the Plex app on all sorts of devices, such as the Apple App Store, Google Play, and even your games consoles. **https://www.plex.tv**

49 Spotify

You'd have to be living under a rock, next to a needle wedged between 25 haystacks, if you haven't heard of Spotify already. Since its launch, the music streaming service has pretty much taken over the way we listen to music. Spotify's free plan gives you access to an incredibly vast online library, and if you can ignore the occasional advertisements and don't want to download songs, this fulfills that need for instant music listening, anytime, anywhere (Wi-Fi signal permitting). **www.spotify.com**

50 Steam

Pretty much the first thing you download after Chrome when you get a new gaming PC, right? Steam is the most reliable source of PC games out there – with a huge library, pretty much any game you can think of will be available via Steam. Its interface is engraved into most gamers' brains, and if it isn't engraved into yours, you don't have enough free time. Steam is an absolutely essential tool for any PC gamer. **https://store.steampowered.com**

System news

In the midst of the silicon shortage Mark Williams is bracing for yet more bad news.

MARK WILLIAMS
Mark is an IT professional with a strong interest in voiding warranties.

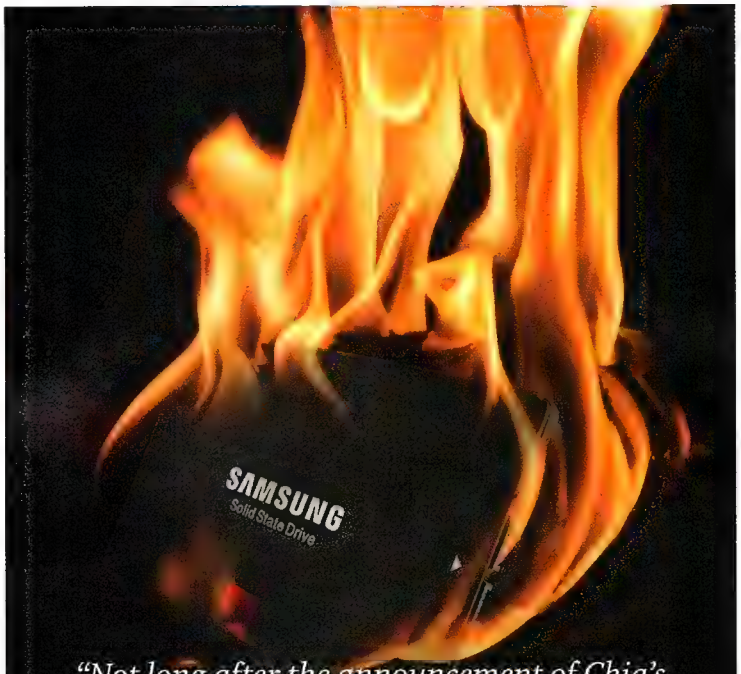
We had hoped the worldwide silicon chip shortage would start clearing up by the end of this year, but all indications are showing that it will be unlikely. With graphics cards still in peak demand and Nvidia and AMD now revising their forecasts from the second half of this year now into next year before supply finally catches up with demand, with the same forecasted for PlayStation 5 stocks, it looks like "winter has come", as the *Game of Thrones* mantra goes.

Unfortunately, just when you think the silicon shortage couldn't possibly get any worse, it does.

Despite the big chip makers pumping out record previously unheard-of numbers of products into the market, and although general consumer demand is by far the main factor for the supply shortage, crypto miners snapping up hardware is a very real concern, effectively preventing cards from getting to end users.

As Nvidia is on the cusp of rolling out its new Ti line of cards, touting hefty crypto restrictions to prevent miners from wanting to buy them, a new kind of crypto mining has just been launched that is shaping up to affect the market yet again. Chia is the name of a new Cryptocurrency designed by Bram Cohen, famously known for inventing BitTorrent, that was designed from the ground up to be a more power-efficient type of Cryptocurrency. Instead of the current energy-intensive "proof of work" model that Bitcoin uses, Chia uses a "proof of space and time" method that is substantially more efficient.

Chia works by creating cryptographic blocks (files) on your storage device called plots, which are cryptographically unique. Creating these plots is quite CPU and memory intensive not to mention write intensive to the drive. Once the plot is generated the plots effectively sit idle (farming) waiting for their unique Crypto number to be called by the Chia network, awarding the lucky owner Chia currency as part of their plot gets added to the blockchain on the network. Being a lottery, the more tickets (plots) you have, the more chances you have of winning. And as each plot can be up to 108GB in size, drive space suddenly becomes a top priority. Which is why not long after the announcement of Chia's launch, reports started surfacing from China where high-capacity SSD and HDD drives were being snapped up en masse, causing their prices locally to quadruple!



"Not long after the announcement of Chia's launch, reports started surfacing from China where high-capacity SSD and HDD drives were being snapped up en masse, causing their prices locally to quadruple!"

Speaking to Richard from Aftershock PC, he confirmed that word is coming from his suppliers that a drive shortage is coming and will likely hit Australia soon once current stock levels are worked through.

And if the demand issue wasn't bad enough, demand from Chia miners will likely continue as Chia plotting is so disk write intensive, where each 108GB plot requires 1.8TB of host writes to the drive. As a result, Chia miners are finding their cheap 256GB SSDs are surpassing the drives' rated Terabytes Written (TBW) write endurance ratings and becoming inert and unusable within a month of usage, forcing those miners to go buy yet more drives to continue farming with.

It certainly seems like a bleak time ahead for anyone wanting to buy or build a PC this year. When will the madness stop?

Shop talk

How are SSD and HDD supplies and prices tracking currently? Do you think Australia will see an impact from this new form of crypto mining?

RICHARD, AFTERSHOCK PC:

"We keep getting told by the distributors that supply is about to get very tight, very soon, on HDDs and SSDs, although we haven't seen it trickle through yet. At the moment we can get all the stock as usual, and the price hasn't risen yet.

I think it will certainly impact us, but it is probably a delayed impact while the distributors move through the current stock they have. Then we will likely see shortages as well as price hikes I imagine."

Market snapshot

An overview of typical systems in today's market.

JW Computers GMR Hawk 3070

$3,098 | tinyurl.com/APC495JWC

This is a system for those who want quality. While this will perform exactly the same as the $2,549 Centre Com system in this month's round up, as the CPUs are the same and the GPUs are basically equivalent (ignoring ray tracing), this system justifies the extra $549 with the quality of the rest of the system. It has a higher-specced X570 motherboard offering more IO connectivity and bandwidth, higher-rated memory modules, and a larger SSD and PSU, making this ideal for anyone who will be wanting to tinker and upgrade their PC over time. The only real shortcoming is the use of the stock AMD CPU cooler. Invest in a good cooler as part of the upgrades and you are off to the races. A great build for those who know what they want.

CPU: AMD Ryzen 5 5600X, **Cooler:** OEM, **Motherboard:** MSI Mag X570 Tomahawk WiFi, **Graphics:** MSI Gaming X Trio Nvidia GeForce RTX 3070 8GB, **Memory:** G.Skill Trident Z Neo 16GB DDR4 3600MHz RGB, **Storage:** 1TB M.2 NVME Samsung 970 EVO PLUS SSD, **Power Supply:** CoolerMaster MWE 750W, **Case:** Nzxt H511.

PC Case Gear Bolt 1650 Super

$1,499 | tinyurl.com/APC495PCC

With a rare-as-hens-teeth CPU in the 3300X, this system should be something of a prize to those that can get one. This is one of AMD's rarer quad-core Ryzen CPUs, equivalent to the i3-10100 found in the PLE system. The big difference here is the word 'Super' at the end of GeForce GTX 1650 Super. That equates to a solid 40 percent uplift in performance capability over the non-Super variant. Currently, 1650 Supers run about $150 dearer, so why might this system be another $100 more over the PLE system? It appears to be a larger 2TB HDD and higher rated 3200MHz RAM. Not worth the extra money really, but these are hard times for supply. A great system for 1080p gamers that is a fraction too costly.

CPU: AMD Ryzen 3 3300X, **Cooler:** OEM, **Motherboard:** Asus Prime B450M-K, **Graphics:** Asus ROG Strix GeForce GTX 1650 Super OC 4GB, **Memory:** Team T-Force Delta RGB 16GB 3200MHz CL16 DDR4, **Storage:** Kingston A400 SATA SSD 240GB, Seagate Barracuda 2TB HDD, **Power Supply:** Aerocool Aero 550W, **Case:** Aerocool Bolt RGB.

PLE Computers Orbit

$1,249 | tinyurl.com/APC495PLE

This entry-level system sticks with the basics of many modern systems, with 16GB of system memory, a 250GB SSD for the system drive, and 1TB of hard drive space. All quite common and most importantly, cheap. With the quad-core CPU at its heart, it will run most games at 1080p with the paired GTX 1650 (non-Super), but don't expect performance beyond 60fps in most titles. In fact, closer to 30fps will be this system's norm. If you are looking to dip your toes into PC gaming, this might be a system worth testing the waters with. The number of fans in this system is kind of hilarious for the small amounts of performance on offer here, but at least it'll look nice and will give any budding PC enthusiast the warm and fuzzies.

CPU: Intel Core i3 10100, **Cooler:** OEM, **Motherboard:** Gigabyte B460M D2V, **Graphics:** Asus GeForce GTX 1650 OC 4GB, **Memory:** Geil 16GB DDR4, **Storage:** WD Blue SN550 250GB NVMe SSD, WD Blue 1TB HDD, **Power Supply:** Not specified, **Case:** SilverStone FARA B1 Pro RGB.

Centre Com Venom Zen3 6700XT

$2,549 | tinyurl.com/APC496COM

This is as nice as it gets – perfect sweet spot material here. Enough performance to do just about everything without breaking the bank. The gaming CPU champ in the 5600X is matched with a 3200MHz pair of DDR4 sticks which is perfect for this class of system. With a tower cooler to boot, the CPU will be happy spitting out 144fps all day long via the RX 6700 XT, which just about matches RTX 3070 levels of performance meaning high FPS 1080p gaming can be had on modern titles, as well as up to 100fps in 1440p gaming and even allow you to explore ray tracing at those resolutions or even 4K rasterised gaming at 60fps. Be mindful of the large unfiltered gaps around the side and front panels, this case could be quite a dust magnet.

CPU: AMD Ryzen 5 5600X, **Cooler:** Cooler Master Hyper 212, **Motherboard:** Asus TUF Gaming B550M-PLUS (WI-FI), **Graphics:** Sapphire Radeon RX 6700 XT Nitro+ Gaming OC 12GB, **Memory:** Team T-Force Delta RGB 16GB 3200MHz DDR4, **Storage:** Kingston SA2000M8 500GB NVME SSD, 2TB HDD, **Power Supply:** Cooler Master MWE V2 650W, **Case:** Karuza V5 Venom TG.

PC BUILDER

Budget

Competent.

We're not sure if we should be celebrating the fact that scalper prices are finally coming down with these graphics cards, but, er, scalper prices are finally coming down with these graphics cards – so, hooray! Instead of being near three times the RRP, they're now only twice as expensive, at least with the RX 6700 XT; the RTX 3060 is still three times the price, but it's down from last month. We have a hunch that the only folk buying these cards at these prices are scalpers, trying to make a quick buck, but because the demand is decreasing as the cryptoboom seems to be easing off slightly, the prices for these GPUS are falling, too. It's a slow meander down, sure, but it does look promising.

At the time of writing, the value of Bitcoin has also tumbled, as the US Biden administration has announced potential tax changes for high earners, which will no doubt also have an effect. As demand for mining falls, due to the volatility of some of those coins, availability and reasonable prices for GPUs are likely to become more commonplace as well.

We haven't changed too much otherwise across the two builds – motherboard and memory prices are still slowly creeping up, so we've had to go for the cheapest compatible parts we could find. Hyper 3600MHz kits are especially cheap right now, with the RGB version cheaper than the non, and they offer more speed than we're used to fitting out in this budget build, so while that lasts we're taking advantage and slotting in these lovely 3600MHz kits.

We're still waiting on Intel to release its lower-end processors in its 11th Gen lineup, but once it does, the Core i3-11100 or 11300 with Intel Xe graphics (if the company goes that route) could be a potent budget gaming chip. The same goes for AMD, we're also expecting to see a new series of Ryzen 5000 chips with integrated graphics, similar to the current chip we're recommending, but based on the Zen 3 architecture.

AMD INGREDIENTS

PART		PRICE
CASE	CORSAIR 4000D AIRFLOW	$130
PSU	450W CORSAIR CV 450 80+ BRONZE	$89
M/BOARD	ASROCK B450M-HDV R4.0 **NEW**	$85
CPU	AMD ATHLON 3000G	$199
GPU	AMD RADEON RX 6700 XT 12GB	$1,200
RAM	16GB (2X 8GB)HYPERX FURY DDR4 RGB DDR4 @ 3600 MHZ **NEW**	$130
SSD	250GB SAMSUNG 980 PRO M.2 PCIE 4.0	$110
HDD	1TB SEAGATE BARRACUDA 1TB 7200	$55
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		$2,058

INTEL INGREDIENTS

PART		PRICE
CASE	CORSAIR 4000D AIRFLOW	$130
PSU	450W CORSAIR CV 450 80+ BRONZE	$89
M/BOARD	MSI B460M PRO **NEW**	$120
CPU	INTEL CORE I3-10100	$179
GPU	NVIDIA GEFORCE RTX 3060 12GB	$1,100
RAM	16GB (2X 8GB)HYPERX FURY DDR4 RGB DDR4 @ 3600 MHZ **NEW**	$130
SSD	250GB SAMSUNG 970 EVO PLUS M .2 PCIE 3.0	$85
HDD	1TB SEAGATE BARRACUDA 1TB 7200	$55
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		$1,948

PC BUILDER

Mid-range

Decent.

Similar to our budget build, we've once again seen prices fall in the scalper market, suggesting that the cryptoboom might be slowing down. It's not quite as dramatic as the budget build, but it's still enough to make us hope for a better future, and not be tied to the inevitable randomness of retailer suffles. GPU situation aside, we're still seeing the slow creeping up of memory prices. We've decided to stick with the same kits as last issue for these two builds.

The biggest change, however, is with the Intel build: We've bitten the bullet and gone for the latest 11th-gen processor, in the form of the Core i7-11700K. Unlike the i9-11900K, which was missing a few cores, the 11700K packs the full complement of eight cores that its predecessor series had, but with added PCIe 4.0 support and a big boost to single-core IPC performance, which makes it an obvious upgrade. It's also given us the chance to swap out the SSD.

The Corsair Force MP600, with its hefty heatsink, is a good PCIe 4 SSD for both Intel and AMD builds.

Frustratingly, motherboard prices have jumped a bit for the Z590 series, so we've gone for one of the cheapest boards we can get (that won't make the PC-O11-Dynamic look as empty as a pandemic-closed concert hall). There is an Asus M-ATX board that's slightly cheaper, the Prime Z590M-Plus, but we're talking a very minor difference.

As for our AMD build, stock is still looking scarce for fifth-gen chips, and our pick from last issue, the Ryzen 5 3600, is now out of stock, pushing us to get the slightly pricier 3600X instead. We're hoping to see AMD drop a new generation of processors later this year, but, well, it's anyone's guess as to what availability is going to look like with that.

AMD INGREDIENTS

PART		PRICE
CASE	LIAN LI PC-O11-DYNAMIC	$199
PSU	650W EVGA SUPERNOVA GA **NEW**	$109
M/BOARD	ASROCK X570 PHANTOM GAMING 4S	$195
CPU	AMD RYZEN 5 3600X **NEW**	$339
COOLER	240MM COOLER MASTER MASTERLIQUID ML240L RGB **NEW**	$90
GPU	NVIDIA GEFORCE RTX 3070 8GB	$1,500
RAM	16GB (2X 8GB)HYPERX FURY DDR4 RGB DDR4 @ 3600 MHZ	$130
SSD	500GB CORSAIR FORCE MP600 M.2 PCIE 4.0 **NEW**	$270
HDD	1TB SEAGATE BARRACUDA 1TB 7200	$55
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$2,947**

INTEL INGREDIENTS

PART		PRICE
CASE	LIAN LI PC-O11-DYNAMIC	$199
PSU	650W BE QUIET! STRAIGHT POWER 11 **NEW**	$149
M/BOARD	MSI Z590-A PRO **NEW**	$289
CPU	INTEL CORE I7-11700K **NEW**	$599
COOLER	ENERMAX LIQMAX III 240 ARGB **NEW**	$99
GPU	AMD RADEON RX 6800 XT 16GB	$1,800
RAM	16GB (2X 8GB)HYPERX FURY DDR4 RGB DDR4 @ 3600 MHZ	$130
SSD	500GB CORSAIR FORCE MP600 M.2 PCIE 4.0 **NEW**	$180
HDD	1TB WESTERN DIGITAL CAVIAR BLUE 7200	$55
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$3,560**

PC BUILDER

Turbo

Stupendous.

It's happening: The scalpers are eating each other; prices are falling. Our system builds are seeing slight drops in some components, too. It's not anything like the prices of old, but it's a start. We are also hearing mutterings of the RTX 3080 Ti making its way to our shores soon, and this card has a combination of hardware and software workarounds that should block performance from cryptomining. We'll wait and see how that pans out, but if true, it should alleviate some of the pressure on the market, and provide us with a semi-tolerably priced card to pop in our turbo builds.

Outside of that, the biggest changes come from our ditching of those premium 360mm AIO coolers for something more down to earth. For the AMD build, we've gone with a sleek little EK number, the EK-AIO Basic; despite the odd naming scheme, it's a subtle black design that is almost identical to the EK-RGB variant we're using in this issue's build. For our Intel system, we've gone with the Be Quiet! Pure Loop 360mm.

For our AMD system, we've also upgraded our motherboard to something more modern. For our Intel build, we can't recommend the Core i9-11900K just yet – yes, single-core performance is higher, but losing those extra two cores and four threads doesn't make it a compelling sell compared to the 10-core, 20-threaded 10900K, at least, not in multithreaded applications.

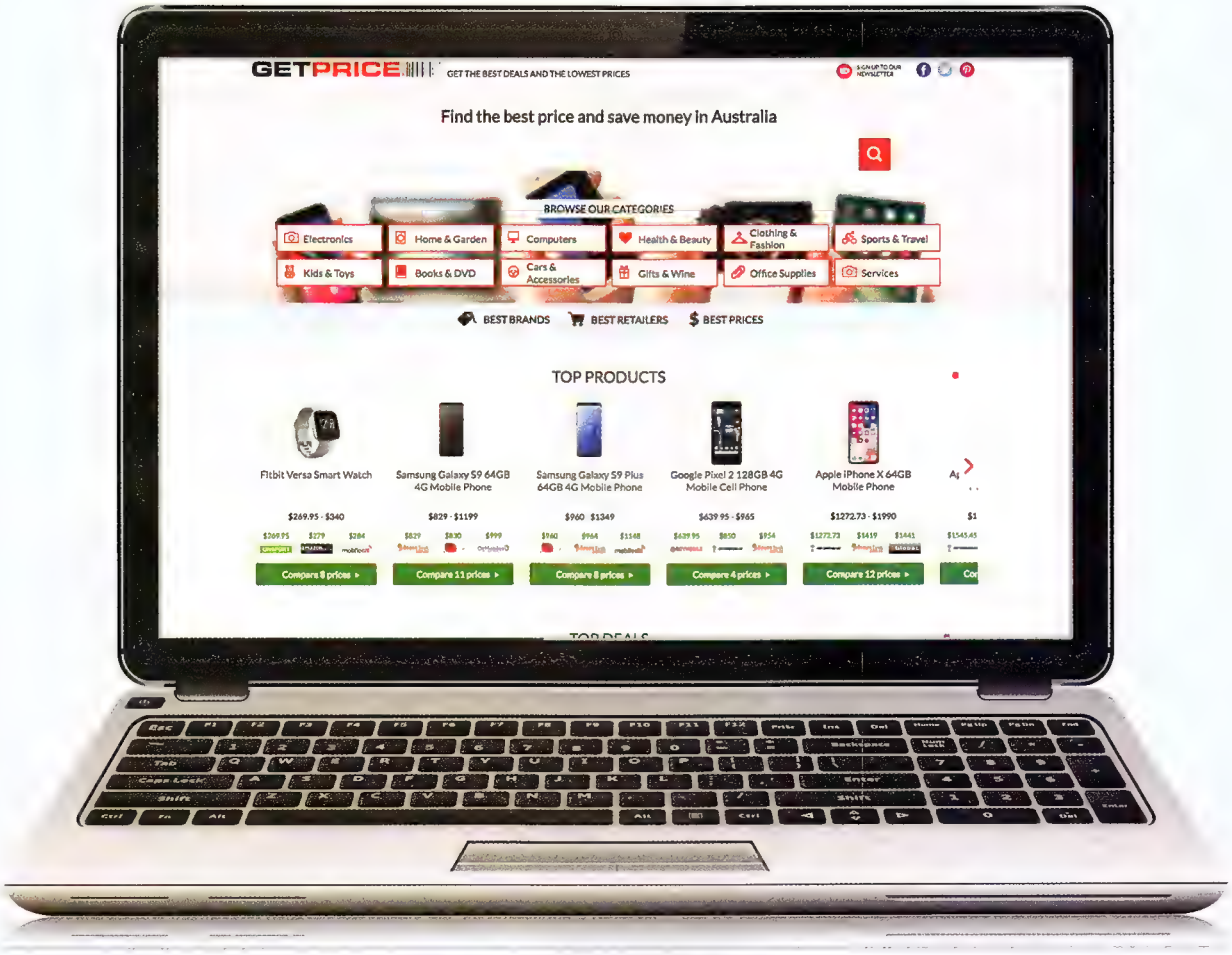
If you absolutely must have PCIe 4.0 speeds, and can't wait for the 12th gen chips to launch later this year, we recommend picking up the 11700K we suggested in the previous build, as that should cover things and save some cash compared to the 11900K, which you can put toward the 10nm chips launching later this year, hopefully.

AMD INGREDIENTS

PART		PRICE
CASE	PHANTEKS ENTHOO PRO 2 TEMPERED GLASS	$219
PSU	750W PHANTEKS AMP 750 W 80+ GOLD	$139
M/BOARD	ASROCK X570 STEEL LEGEND WI-FI AX **NEW**	$295
CPU	AMD RYZEN 7 5800X	$669
COOLER	EK EK-AIO BASIC 360MM **NEW**	$300
GPU	NVIDIA GEFORCE RTX 3080 10GB	$2,200
RAM	32GB (2X 16GB) TEAM T-FORCE DARK ZA DDR4 @ 3,600MHZ	$249
SSD	1TB AORUS PCIE 4.0	$270
HDD	6TB WESTERN DIGITAL BLUE	$260
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$4,661**

INTEL INGREDIENTS

PART		PRICE
CASE	PHANTEKS ENTHOO PRO 2 TEMPERED GLASS	$219
PSU	750W SEASONIC FOCUS PLUS GOLD 80+ GOLD	$199
M/BOARD	GIGABYTE Z590 AORUS ELITE **NEW**	$299
CPU	INTEL CORE I9-10900K	$749
COOLER	BE QUIET! PURE LOOP 360MM **NEW**	$160
GPU	AMD RADEON RX 6900 XT 16GBNO STOCK	$2,600
RAM	32GB (2X 16GB) G.SKILL TRIDENT Z NEO RGB DDR4 @ 3,600MHZ **NEW**	$280
SSD	1TB CORSAIR MP400 M.2 PCIE 3.0	$280
HDD	6TB WESTERN DIGITAL BLUE	$260
OS	WINDOWS 10 HOME 64-BIT OEM	$60
PRICE:		**$5,106**



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BUILD IT

Upgrades, upgrades, upgrades

Z490 with an 11th-gen chip. Is it worth it?

LENGTH OF TIME: 1-2 hours
LEVEL OF DIFFICULTY: Easy

Let's face it, Intel's latest launch has been a little lackluster. At least at the top end. The Core i9-11900K is, technically, a fantastic piece of engineering (a compliment we keep having to throw Intel's way these days), because it circumvents a lot of the limitations of 14nm and the previous architecture design. However, when it comes to outright performance and pricing, Rocket Lake sort of falls flat on its face rather swiftly – at that aforementioned top end, anyway. That's not good. We really need Intel to break through that 10nm barrier, and deliver, en masse, newer chips for the health of the industry as a whole. Regardless of whether you're a fan of Team Red or Team Blue, having two competitive chip makers means that we, the consumers, will see significant improvements, generation to generation. And that's something that, apart from meaning faster, better-performing rigs for us, also extends to benefiting society. Heck, we don't want to see this all boil down to ARM versus AMD, RISC versus x86, in 10 years' time. That would be sad indeed.

So, was everything a dud in Intel's latest launch? Well, no. Bizarrely, and in perhaps the biggest turn-around in history, Intel's budget-oriented chips are actually far more interesting than those at the top of the stack, and even more so than AMD's. The Core i5-11400 and Core i5-11600K in particular are quite interesting, especially for those who only have one ambition for their rigs: gaming. In fact, in many cases, they entirely outpace their red rivals at the lower end of the spectrum. Long gone are the days of "If you're on a budget, go AMD." Yet there's a catch....

The impossible task

There's just no way of getting out there and buying modern components today. It's almost impossible outside of a select few areas. Storage, power supplies, cases, cooling, peripherals, some motherboards, and Intel CPUs are in steady supply, no doubt the latter due to the 14nm process being fairly under-utilised at this point by the majority of the industry. But trying to find a graphics card in this hellish mining boom ecosystem is nigh-on impossible.

We're very fortunate, with the fact that there are indeed some press samples in circulation that we can take advantage of here at *APC*. Not least the card we've chosen for this issue: AMD's latest Radeon RX 6700 XT. But even we've had to borrow this card specifically from our colleagues at *PC Gamer* for a week, purely to build, shoot, and test this system, because AMD had no spare samples available for us.

So, we're pitching this build around the concept of an upgrade, effectively. You've had the majority of these parts for a while now. You managed to pick up a Core i5-10600K way back when it launched in 2020 (yikes), along with a Gigabyte Z490 motherboard, complete with PCIe 4.0 compatibility, and thanks to being extremely lucky with some pre-orders, got hold of a 6700 XT and an i5-11600K, although the chip wasn't exactly too difficult to source.

The big question: Does the Z490 board do the job with the latest-gen chip? And if you were to build this rig from scratch, what would $3,8501 get you in terms of gaming performance in this silicon drought-ridden world we live in? Let's find out.

Ingredients

PART		STREET PRICE
CASE	LIAN LI PC-O11-DYNAMIC FULL TOWER	$199
MOTHERBOARD	GIGABYTE Z490 AORUS PRO AX	$399
CPU	INTEL CORE I5-11600K	$369
GPU	AMD RADEON RX 6700 XT	$1,100
MEMORY	16GB (2X 8GB) CRUCIAL BALLISTIX DDR4 @ 3,600	$300
PSU	850W BE QUIET! DARK POWER 12 80+ TITANIUM	$340
PRIMARY STORAGE	1TB SAMSUNG 980 PRO M.2 PCIE 4.0 SSD	$259
SECONDARY STORAGE	2TB WESTERN DIGITAL SN750 M.2 PCIE 3.0 SSD	$450
CPU COOLER	360MM EKWB EK-AIO D-RGB	$299
FANS	3X PHANTEKS PH-F120SK	$75
OS	WINDOWS 10 HOME 64-BIT OEM	$60
TOTAL		$3,850

"We're very fortunate, with the fact that there are indeed some press samples in circulation that we can take advantage of here at APC. Not least the card we've chosen for this issue: AMD's latest Radeon RX 6700 XT."

01 LEGENDARY LIAN LI

Why we've never done a "Build It" using the legendary Lian Li PC-O11-Dynamic chassis before is beyond us. It seems to have slipped through the net at *APC*. We've used it across other brands, and we've known for years that it's exceptionally well built. In fact, it's perhaps the best case available right now for anyone looking to build in an ATX tower. And yet, somehow – amid all its accolades and awards – we've never thought once of documenting a build in it, outside of recommending it for "Blueprints," of course. Crazy.

The O11-Dynamic is an absolute beast. It is a full-tower, cube-shaped, dual-chamber case, with capacity for up to three 360mm radiators in the front alone, E-ATX motherboard support, dual power supply options, and vertical GPU support, along with enough accessories to make your eyes bleed, all packed together with a lovely flourish of smart brushed aluminum and tempered glass. And the cherry on top? You can also pick it up in silver.

02 INTUITIVE PANEL REMOVAL

Getting to grips with it, the first thing we did was strip our case down to its bare bones. The PC-O11 has quite an original design when it comes to removing the panels. First, you remove the top of the case; there are two thumbscrews at the back to loosen. Once that's off, the two glass panels, secured by a stealthy notch and latch mechanism, lift up and out. It's all super-clean and surprisingly secure for a chassis of this size.

There are no thumbscrews, magnetic hinges, or anything along those lines, giving it a super-tidy look overall. We've also gone ahead and removed a few interior panels here, namely the 3.5-inch hard drive cage above the PSU, as well as a cable tidy bar, just to give us as much room as possible to work in.

02 MOTHERBOARD PREP

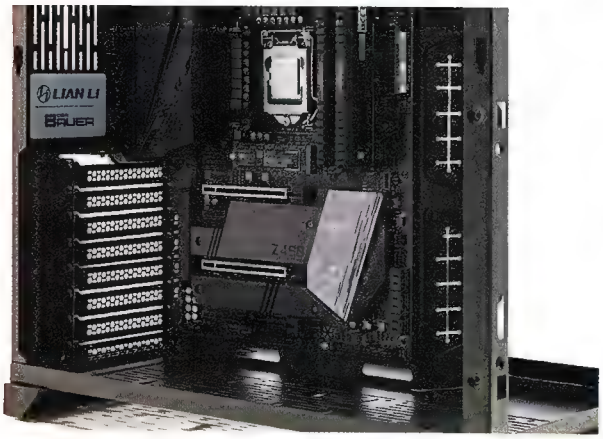
Next on the agenda is our motherboard, the Z490 Gigabyte Aorus Pro AX. If you do plan on using a Z490 board, you need to update the BIOS to the latest version. Note, most Asus boards don't support 11th-gen chips or PCIe 4.0 devices, so double-check before investing in a new CPU that your board can support it.

To update your BIOS, you need a USB stick, formatted to FAT32. Download the correct BIOS version from the mobo's support page (for the Gigabyte Z490 Aorus Pro AX, we need the F20d BIOS released on March 12), and extract it to the stick. Once the PC's built, pop in the stick, power on the rig, mash the Delete key, and look for the BIOS Flash tool in the BIOS. Select the file on the USB stick and wait while it does it's magic. Word of warning: Although BIOS updates almost always go smoothly, things can go wrong; make sure you don't power off the system during the upgrade, or you could brick the board. We often upgrade the BIOS just prior to installing Windows, placing the BIOS file on the same USB stick that we use for the Windows 10 installer, as the Media Creation tool formats the USB stick to FAT32.

03 PCIE 4.0 TESTING

Our storage for this build isn't technically what we would recommend for this kind of spec. Basically, it's massive overkill. A 1TB PCIe 4.0 drive for your operating system will be zippy as heck, but at $260, it's hardly cheap – same goes for the 2TB PCIe 3.0 drive we're running for backup storage. These two drives are purely here to see how they perform on a previous-gen motherboard, which is supposedly PCIe 4.0 compatible, with a BIOS upgrade, and Intel's first gen of PCIe 4.0-supporting processor.

That's not to say these aren't fantastic components. Indeed, the 980 Pro would be our PCIe 4.0 drive of choice (that, or the Sabrent Rocket 4 Plus) for anyone looking for a high-spec enthusiast-class primary drive.



04 ROOM FOR ACTIVITIES

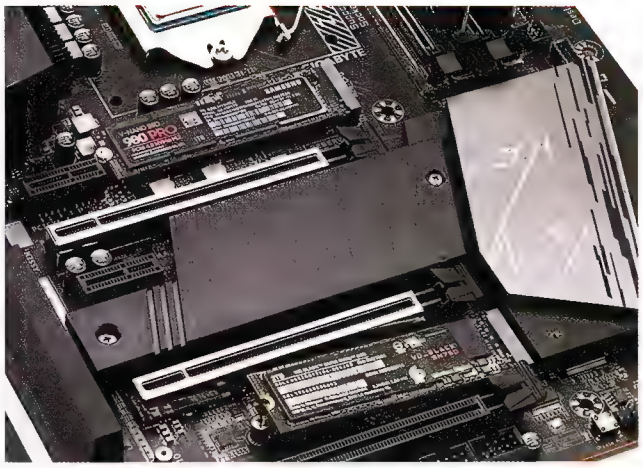
To install the motherboard, line up the holes in the board with the stand-offs in the case, and the integrated rear I/O shield with the cutout in the back of the chassis, and place it down. It's best to do this with the case on its side, so you're not fighting gravity. Then, carefully secure the motherboard into position. Make sure you use the correct screws, so you don't strip the stand-off threads. There's nothing worse than using the wrong screw, then having the stand-off spin as you try to free your trapped motherboard if something goes wrong.

Also, check out all the space. It's a seriously big case, and the angled cable grommet area allows larger E-ATX boards to fit in, albeit with a slight overhang.

05 REAR I/O & HDDS

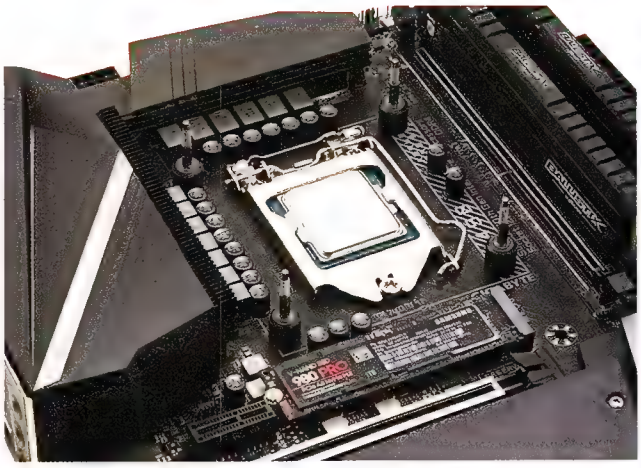
Here you can see we've removed the hard drive cage from the back of the chassis, as our build technically doesn't require it. This has given us some extra cable management space, although, to be fair, given the design of this chassis, that's never going to be a problem.

Perhaps the oddest element of the PC-O11-Dynamic is the recessed rear I/O portion of the chassis. Don't get us wrong, it's a classy case, but it seems strange to recess the I/O so far back, especially as light is traditionally hard to come by when plugging cables into the back of the motherboard tray like this.



06 THE RIGHT SLOT

Because Z490 and PCIe 4.0 are fickle friends, installing your storage correctly is vital. The PCIe 4.0-compatible slot on the Z490 Aorus Pro AX isn't documented on Gigabyte's website, but it's this top slot. The manual states that this slot is called M2B_CPU (note: reserved), and has no use. But the two other M.2 slots under the heatsink are labeled M2A_SB and M2M_SB, SB standing for southbridge, or the chipset. Intel's 10th-gen chips don't have the PCIe 4.0 lanes capable of driving that slot at the top (reserved for 11th-gen chips and PCIe 4.0), and the two southbridge slots go via the DMI in the Z490 chipset, which connects to the CPU, operating at PCIe 3.0 x4. Pop in an 11th-gen chip, update the BIOS, and the top slot operates in PCIe 4.0 x4 mode direct to the CPU. Neat.



07 MOUNTING IS GO

With all that storage fun out of the way, and the memory and processor installed with the motherboard outside of the case, it's time to start installing the backplate. EK's backplate system is far less complex than the Be Quiet! one we were fandangling with last issue, that's for sure. Line the backplate up on the rear of the motherboard, and secure the stand-offs in position through the four mounting holes. Turn these by hand, so you don't overtighten them, and you'll be good to go.

Once that's all wrapped up, it's time to get the motherboard into our shiny, empty Lian Li chassis.

"Our power supply of choice for this rig is the Be Quiet! Dark Power 12 850W. It's a beast, and Be quiet!'s really nailed down its aesthetic to a T: silver-embossed logos, super-slick industrial-style grilles, and, of course, an epic fan at its heart."

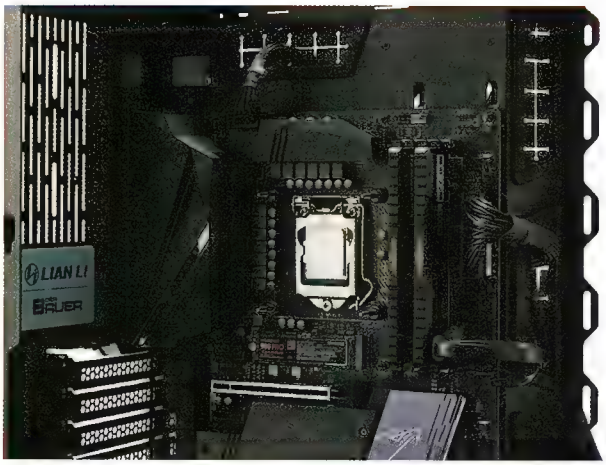
08 NO, SERIOUSLY

It's a crazy amount of room. In fact, you can install twin power supplies in the back if you want. Lian Li includes a fairly substantial rubber block you can use here, which sits between the two PSUs, stacked sideways on top of each other. If you did want to go that route with a single system, you'd have to find some way of bridging them, so they both initialise at the same time. Phanteks used to sell a power combo that could do that for you, but it seems to no longer be available. This element is a little odd, if we're honest, as there's not really space for a secondary ITX system, where it would make a lot more sense.

09 ALL OF THE POWER

Our power supply of choice for this rig is the Be Quiet! Dark Power 12 850W. It's a beast, and Be Quiet!'s really nailed down its aesthetic to a T: silver-embossed logos, super-slick industrial-style grilles, and, of course, an epic fan at its heart. This 850W PSU is more than enough for what we're building here today; in fact, it's over twice what we think this system will draw from the wall. It also comes with some flashy, overly large thumbscrews.

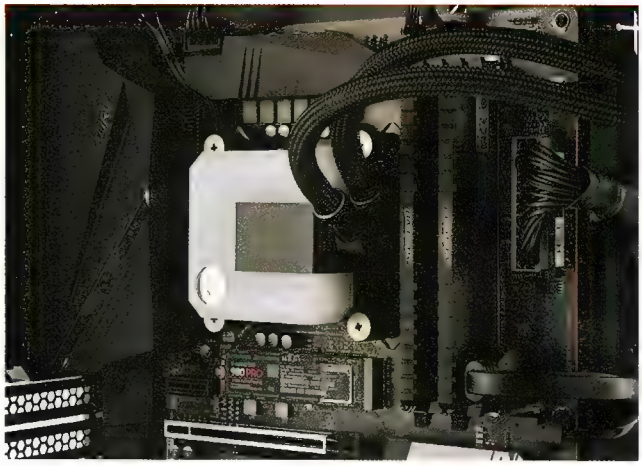
It's slightly less flashy than the Dark Power Pro 12 series, and doesn't come with pre-sleeved cables, but practically everything else is the same, even the efficiency rating. So, if you're just looking for a top-notch power supply without the fluff, it's a good pick.



05 CABLING BEFORE ALL

Yeah, we decided to go this route this time around and install the cables first – basically, because we weren't quite sure how to install the AIO. Traditionally, they're something you install in the roof; that said, in our 5000D, we managed to install it in the side of the chassis, and that looked pretty stellar.

To that end, we decided to run all the cables first. There's nothing too out of the ordinary here, although one thing we will point out is that the USB 3.0 and USB C headers look rather ugly, due to the position of the connectors on the board, and that angled cable management grommet system we were praising earlier.



06 SPLODGE? SPLODGE!

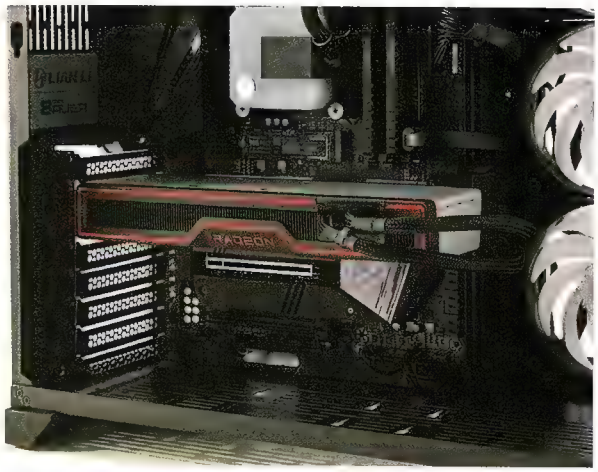
With all the cables we needed installed (opting for a single eight-pin EPS power for this setup), we installed EK's 360mm AIO block on the board. This was a cakewalk, and once again goes to show just how nice this thing looks on a board with enough space (here's looking at you, Z490-I ROG Strix Gaming).

Simply attach the Intel bracket to the waterblock, remove the protective film underneath, add a splodge of your favorite thermal paste, position the block over the stand-offs, place the tiny springs over the stand-offs, and secure down in a star pattern, using the included screws. You can use a screwdriver to finish off the job – just make sure you don't use an electric one, or you may overtighten the cooler and crack the CPU's PCB.

07 FAN-TASTIC OPTICAL ILLUSIONS

We decided to run the AIO out through the roof, and set up the three EKWB fans as exhausts. The only downside to the Lian Li PC-011-Dynamic is the lack of fans. You're expected to provide your own. We've gone with three 120mm Phanteks RGB fans acting as an exhaust; with their typhoon-style blades and side-mounted location, the image below can play tricks on your eyes.

If you struggle with daisy-chained RGB connectors, we recommend using parcel tape, gaffer tape, or electrical tape to stick the RGB connectors together loosely around the back, so they don't come undone. Works a treat!



08 THE RARE SPOTTED RX 6700 XT

These things should be designated an endangered species at this point. Our final step in the whole build process was installing our shiny new AMD Radeon RX 6700 XT. We removed the two PCIe covers from the back of the case, lined it up with the uppermost PCIe slot, and slotted it into position, before resecuring it back down, and installing the PCIe power cables that we'd left out specifically for it earlier.

This is one of the "Made by AMD" models, and as such it's, well, got bright red accents on it. Somewhat annoying. AMD did release a Midnight Black version earlier this month, but perhaps unsurprisingly, they were sold out within seconds, and immediately relisted on eBay for three times the RRP. Yay.

01 At the moment, we're running a heavily negative pressure system; installing three intake fans in the floor would help remedy that.

02 A nicer-looking graphics card without the red accents would help, too, but let's be fair, we should be happy we have a card at all.

03 If you were running this rig for personal use, day in day out, we'd swap the three side fans here, so they were intakes instead.

04 The 980 Pro SSD below the CPU may not have a heatsink, but its natural copper-laced sticker should help keep it cool.

Retro boards

There you have it: one crisp clean Lian Li upgrade build, complete with PCIe 4.0 drive, Intel Core i5-11600K, and AMD Radeon RX 6700 XT. We're super-happy with how it turned out, even if it is running in a negative pressure configuration. It looks excellent, and that RGB fan setup is looking fine. Ideally, it does need a few extra fans; three intakes in the bottom blowing cool air up into that GPU would add an extra splash of light and help with temperatures. The PC-O11-Dynamic is what we call a chimney or funnel design – unlike most cases that draw cool air in through the front and exhaust it up and out, a chimney design is assisted by natural convection, as it pulls cool air in through the bottom and then pushes it up and out through the roof. That's why the O11 has a magnetic dust filter below those bottom three intakes.

The build itself went super-smoothly. The one thing we would say is that installing the radiator in the roof was a little tricky, as it doesn't have a removable radiator bracket, but having one there would add to the bulk, and may have led to an uglier finish aesthetically. And let's face it, you install a radiator once, it takes five minutes of messing around, then it's in place for the next six months to several years anyway.

As for performance, the Core i5-11600K is a fine piece of gear. In multicore performance compared to last-gen's 10600K, we're seeing figures 20 percent higher across rendering tasks, which is impressive, and it also does better in gaming, no doubt thanks to higher single-core IPC. It's not quite as big a difference compared to AMD's Ryzen 5 5600X as we'd like, but all things considered, it's not bad, and it is cheaper and in stock. We were worried about PCIe 4.0 performance, given the fact that it's an older series motherboard, but performance with the 980 Pro landed right where we expected it, with reads in the high 6,000s and writes in the low 5,000s.

We decided to compare this rig against a similarly priced machine from last year, our Razer Tomahawk ITX build, which housed the RTX 2080 Super from Zotac. Impressively, the RX 6700 XT could easily keep pace with it in 1440p gaming. In fact, in almost every benchmark, it outperformed the old juggernaut by a comfortable 10 percent or so, with the only exceptions being *Total War: Warhammer II* and ray tracing, as the 6000 series doesn't quite have the same dedicated hardware that Nvidia is using to deal with ray-traced shadows and resources.

Question is, should you build this system today? Well, if you have most of the parts already, and feel the need for an upgrade, it's not a bad move. At 1440p, it's a solid build, but you do need to find a GPU, and you are going to be paying $1,100 for the privilege. If you can, snap up a new GPU at retail price or get on a pre-order list. But we recommend you look at eking out extra performance where you can without breaking the bank, namely with your case setup, cooling, and peripherals. In a year or two, hopefully the silicon shortage will end, and you won't be out of pocket sitting on a rapidly depreciating graphics card. ■

APC LABS BENCHMARKS

Indicates best result	Cinebench R15 Multi	CrystalDisk QD32 Sequential	CrystalDisk QD32 Sequential	Red Dead Redemption II	Total War: Warhammer II	Assassin's Creed Odyssey	3DMark: Port Royal
	Index	Read MB/s	Write MB/s	FPS	FPS	FPS	Index
Upgrade Rig	1,689	6,852	5,137	75	82	75	5,838
Zero-point	1,421	3,534	3,170	68	80	67	6,905

Our zero-point consists of an Intel Core i5-10600K, an Asus Rog Strix Z490-I Gaming motherboard, Zotac GeForce RTX 2080 Super AMP Extreme GPU, 16GB of Corsair Dominator Platinum RGB @ 3,600, and a 2TB Samsung 970 Evo Plus M.2 PCIe 3.0 SSD. All games tested at 1440p on the highest graphical profile.

QUICK TIPS

APC experts solve computing problems

The *APC* team tackle problems across the spectrum of devices and software. Learn a new trick or fix you can use.

Frame stutter problem

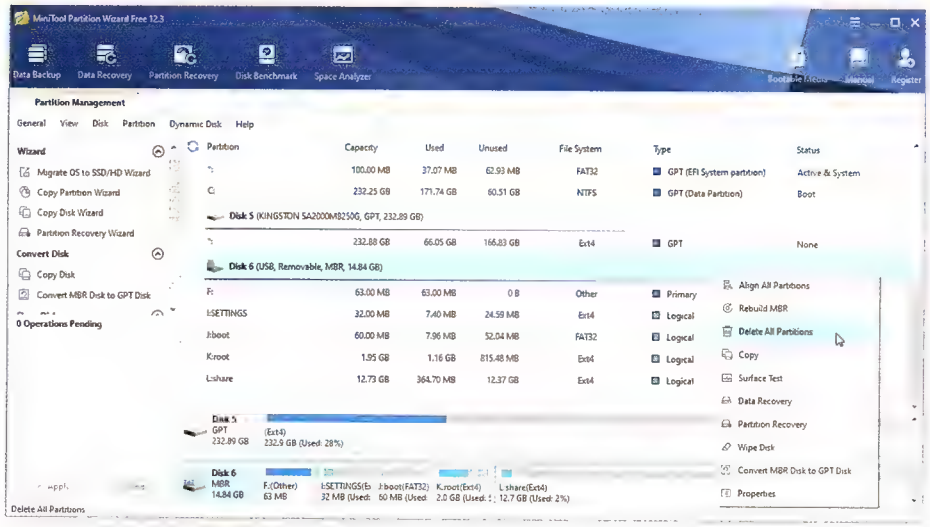
I'm experiencing an intermittent frame stutter issue in games as varied as World of Warships and Ghost Recon Breakpoint. It's not tied to graphics quality settings, as I've tried everything from maxed out to turning them down to mud, and still have the issue. I've tried killing all background apps/processes, I update regularly, whether BIOS, drivers, or firmware. I've tried stock voltages, PBO enabled, Ryzen Master OC, and so on but can't resolve it.

I built my PC in November 2019 – key specs are Gigabyte Aorus Ultra X570 MB, AMD Ryzen 3800X CPU, 32GB (4x 8GB) DDR 3600 RAM with XMP enabled, plenty of cooling, 2TB Seagate Firecuda PCIe 4.0 OS drive, 1TB Samsung 970 Evo PCIe 3.0 auxiliary drive, 2x 3TB Seagate mechanical drives in RAID 1, Windows 10 Home, and I reused my GeForce GTX 1080 Ti from my old rig. My temps are all far below the max thresholds during gaming. I have tried disabling XMP and dropping the memory to 3,200MHz in the BIOS, but still no dice.

I'd love to upgrade to a Ryzen 5900X and an RTX 3080 to try to resolve this issue that way, but we all know the vaporware status of those. Any ideas of what is causing this? Am I running too much gear over the PCI interface and hitting bottlenecks, is the DDR4 3600 the issue, or something else entirely?
BJ KOHO

APC responds: Our first response was to ask about BJ's display setup, as the internet was full of people exhibiting similar symptoms and finding common ground when looking into the connection to their monitors. BJ tried several of the solutions – he verified he was using the DisplayPort and bumped its response time to the maximum. He went into Device Manager, right-clicked "Communications Port," and choose "Properties > Port Settings," where he set "Flow control" to "Hardware," and disabled FIFO under "Advanced." He also uninstalled iCUE and disabled the 0 core in Ghost Recon Breakpoint in Task Manager

This helped a fair bit in *Ghost Recon Breakpoint*, although some frame stutter remained, but had no effect on *WoWS*. Undefeated, BJ kept plugging away and got back in touch two weeks later to share his final solution. While troubleshooting an issue with his Internet connection, BJ – with the aid of his ISP – traced a problem to his modem and router, both of which exhibited intermittent signal loss. He replaced these with a Netgear CM500 cable modem and Asus RT-AX82U router respectively, set up device priority for his PC and the requisite game profiles, and the problem vanished. BJ puts the problem down to the age of his old equipment, but wanted to share his fix in case it helped fellow readers.



MiniTool Partition Wizard can handle troublesome SD cards.

SD card won't format

I have a question about my Dell XPS 13. It has a built-in microSD card reader but when I insert a card and try to format it, I get an error saying that the disk is in use, asking if I want to force-eject it. I've tried disabling background apps, looked into what's running with Process Explorer, and tried different tools to format the card, but no luck. One – GUI Format – throws up the same error, but with no option to force-eject. Another app, SmartDisk FAT32 Format Utility, won't recognize the card as an external drive unless it's plugged into an external reader/hub.
YOSEF SAFDEYE

APC responds: Despite Yosef providing lots of information, we still needed him to answer a few more questions, and Yosef was quick to reply. To summarise: The problem applied to all SD cards, as well as USB flash drives, and when using an external SD hub. The same error popped up when Yosef attempted to format the card in Windows, but clicking "Yes" led to the card being formatted successfully – however, Windows can't format 64GB-plus cards in FAT32 format, which is why he needs a third-party app. Finally, the same error popped up when attempting to eject the card – but this is common and trying again resulted in the "Safe to remove" message popping up.

One potential workaround arose from our conversations: If Yosef rebooted into Safe mode, he was able to format the card with no problems. Other suggested workarounds are to format the

card in NTFS or exFAT first, before trying again with FAT32, or to use a different tool, such as MiniTool Partition Wizard (**www.partitionwizard.com**), which we have used in the past to partition and format drives other tools wouldn't touch.

Yosef was worried the problem was linked to malware – it's not, but there's no harm in a quick security audit. Update and run a full scan with your existing tool – Yosef uses Microsoft Defender – then, if you want additional peace of mind, run scans with two further tools: Emsisoft Emergency Kit (**www.emsisoft.com/en/home/emergencykit**), which combines Emsisoft and Bitdefender virus scanners in a single tool, and Malwarebytes Anti-Malware (**www.malwarebytes.com**), which reverts to a free scan-and-remove tool after the 14-day trial. MBAM's reputation has taken a battering recently, but it does detect unwanted software other tools ignore, so is a good secondary tool.

Optimise MP4s

I recently set up Plex on my Ubuntu server for all my ripped media only to discover loads of files kept buffering when I or friends accessed them remotely. I discovered something called the "moov atom" that needs to be placed at the start of my MP4 files (rather than the end) to facilitate streaming. I know now I need to check "Web Optimised" on the "Summary" tab in Handbrake to set this up for any future files I create, but what about the hundreds of files I've already got?
LIAM MCSHANE

APC responds: Luckily, there are tools that can move the required bits to the start of your file without having to reconvert it. This not only ensures the video and audio quality are unaffected, it's also a far quicker process. You can combine two free tools and a script to perform the task in the background from the command line. First, install the two tools: AtomicParsley for detecting files that need optimising, plus MP4Box – part of GPAC – to perform the optimisation, then download the script:

```
$ sudo apt update && sudo apt install atomicparsley gpac
```

Optimise MP4 files for streaming using MP4Box.

```
$ wget http://muzso.hu/dfiles/public/fix_mp4_moov.sh
```

Open the script in nano ("nano fix_mp4_moov.sh"); the only part of this you need to modify is the "VIDEO_DIR=" variable, which you point to the directory containing media files—for example, VIDEO_DIR='/home/username/media/Movies/'. Save the file and exit. Now launch the script like so:

```
$ ./fix_mp4_moov.sh &
```

We've added the "&" operator to instruct the script to run in the background, so it doesn't tie up your terminal. The process can take hours, depending on how many files need optimising, but you can monitor it using the "htop" tool. Once running (type "htop" and press Enter), press F4, and type "mp4" into the filter box. This enables you to monitor the running processes; you'll see AtomicParsley checking each file and then, when it finds one that needs optimising, handing it over to MP4Box. Files are processed alphabetically, and are listed as they're being processed, providing a progress indicator. Press F10 to close htop and return to the command line at any time.

Alternate NAS motherboard

I read with interest here the letter regarding a NAS. I was wondering if the Asrock J4005B-ITX is a suitable substitute for the board mentioned (Asrock's J5040-ITX)? The latter is out of stock and way overpriced elsewhere.
ANTHRAX.ANCIENT

APC responds: The chip shortage means the J5040-ITX is now virtually impossible to get. It's a shame because it's the perfect board for a NAS. That said, you can do better than a J4005B-ITX – it only offers two SATA ports, which limits you to two internal drives unless you use a plug-in SATA card, which won't perform as well as the native onboard SATA ports.

A better replacement is the Asrock J4125-ITX (which – like the J5040-ITX – is a Gemini Lake Refresh board. It's a Celeron rather than a Pentium processor, but is quicker than the J4005, and comes within 10–20 percent of the J5040's performance. Crucially, the J4125 boasts the same Intel 600 graphics, so it's suitable for hardware transcoding media streams if you want to use the NAS as a low-powered media server.

There are two models. The regular J4125-ITX has four onboard SATA3 ports – two native ports, plus two Asmedia ASM1061 ports. The J4125B-ITX has only two native SATA ports. If you only need up to four drives, the J4125-ITX is clearly the better option, but what if you need more?

The J4125-ITX has a single PCIe 2.0 x1 expansion slot, and you can pick up two- and four-port SATA PCIe x1 cards cheaply on eBay. But with the bandwidth limited to around 500MB/s, and shared with the onboard ASM1061 ports, you won't get maximum performance from all your drives. The J4125B-ITX supports a PCIe 2.0 x16 slot, which maxes out at around 8GB/s, making it more suited for setups where five or more drives are needed; expect to pay north of $100 for an eight-port SATA PCIe x16 card.

Both – like the J5040-ITX – also sport an M.2 slot, but this doesn't support M.2 boot drives. M.2 is overkill for a server that's on 24/7 anyway; just plug an SSD drive into one of the native SATA ports, and install your OS on that. Choose an SSD designed for the unique demands of network servers; *APC* recommends the WD Red SSD 500GB.

Streaming games around your home

What's possible, and how is it done?

While you wait for Google's Stadia and Microsoft's Project xCloud to become viable and available in Australia, did you know it's already possible to stream games you own to devices around your house, including mobiles and TV screens?

You can play your Xbox or Playstation games on your PC, for example; or beam your PC games from your study to your loungeroom TV over your home network; or play your PC games on an Android phone. You don't actually need much to make this happen – a wired home network helps but is not strictly necessary, and the rest is really just software and possibly controllers.

We're not going to look at every permutation and device here (there are a lot), but we thought we'd walk through some of the major options available to you.

Streaming PC games to mobiles or televisions

When we're talking about streaming from a PC there are, as you might expect, quite the array of options. We don't have the space here to look at all of them, but let's start with Steam Link, since a lot of PC gamers will likely have an established library of Steam games and it's relatively simple to get running. Although Steam no longer makes the dedicated Steam Link hardware, a software client for Steam Link is available on Android and iOS (including Apple TV). It's also built into a number of Smart TV platforms (most notably Samsung's), and there is a client available for Linux that can be installed on a Raspberry Pi. Steam also lets you stream from one PC to another, so long as both PCs are logged into the same Steam account, though the process for this is a little different.

To get Steam Link running you need to do two things:

1. Enable Remote Play in the Steam settings. In Steam on the PC you want to stream from, go to Settings > Remote Play and enable it.
2. Install Steam Link on the client platform (iOS, Android or Raspberry Pi). If it's a Smart TV with Steam Link you can just start the app.

You will need a controller (though touch screen control might be possible), and the Steam Link app can pair with a variety of wired and wireless game controllers. After starting the app, it will search your local network for running Steam apps. When it finds it, it will provide a pin number.

3. Head back to your PC running Steam. It should have a popup box asking you to enter the pin number to authorise access.
4. Once you've done that, the client will test the network connection. If it's up to snuff, the Start Playing button will appear. Press it, and Steam on the PC will go into Big Picture mode and will be mirrored on your device.

As mentioned, Windows-to-Windows streaming with Steam is also possible. It's actually done through the main Steam app rather than any Steam Link client. When you have Steam open and logged into the same account on multiple PCs, if you go to your Library on the PC you want to play on you'll have a new option to launch games. Just press the 'Stream' button and it will stream from the host PC.

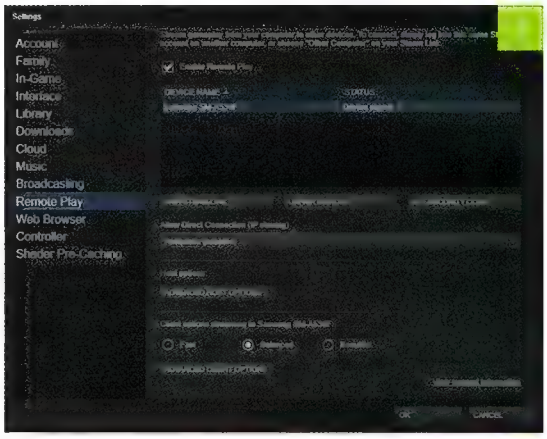
If Steam isn't your bag, then you can try one of the many other options available. Moonlight (**moonlight-stream.org**) requires you have an Nvidia graphics card in your PC while AMD Link (**www.amd.com/en/technologies/radeon-software-amdlink**) requires an AMD card. Rainway (rainway.com), Remotr (remotrapp.com) and Parsec (parsec.app) are more hardware agnostic. Any one of these platforms can stream a PC's desktop display to both Android and iOS devices, and several also include Macs, Linux and Windows PCs in their client lists.

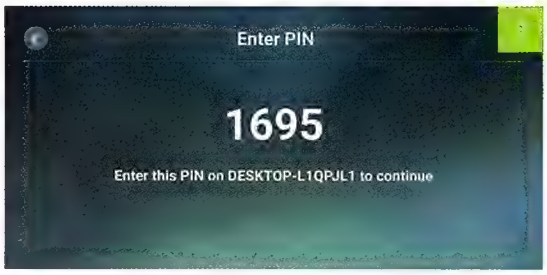
Streaming PC and Android games to Xbox

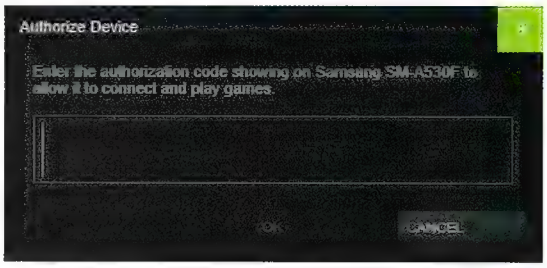
A few years ago Microsoft enabled streaming to Xbox using a version of the Miracast streaming protocol. You need to install the Wireless Display app on your Xbox, which should be available in the Microsoft store on Xbox – just perform a search for Wireless Display. Once you've installed it and have it running, it turns the Xbox into a Miracast (a.k.a. Smart View) client.

Then head to your Miracast/Smart View-supporting Android device and switch it on using whatever Miracast app you're using (there are dozens in the Google Play store). On Samsung devices, launch the SmartThings app, which includes Smart View and then choose the Xbox.

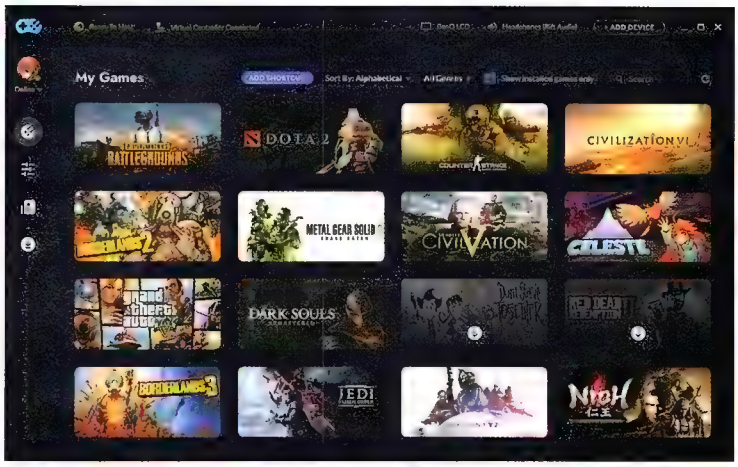
On a PC, press the Windows-P

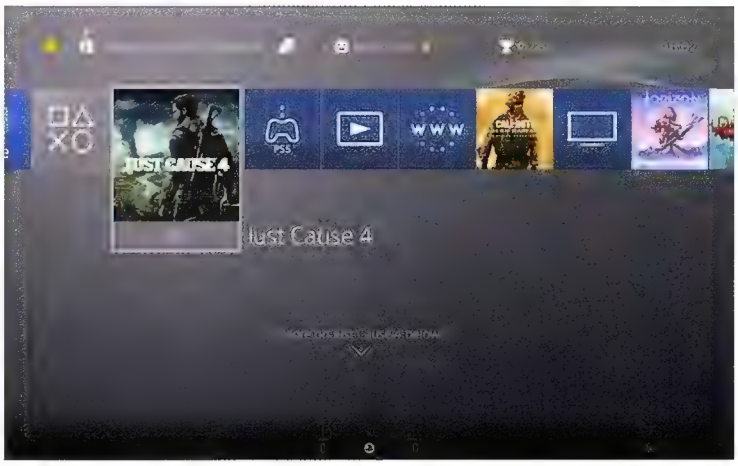






01 Enable Remote Play in the settings. You'll also see a list of devices you've authorised for Remote Play here.
02 The client app will give you a pin number.
03 Enter the pin number into the PC.
04 Ready to rock.





Above: The Xbox will look like this. **Right:** The Rainway interface. **Below right:** PlayStation Remote play running on Windows.

keys to open up the Action Centre and select the Connect to wireless display option. Hopefully your Xbox will appear in the list of possible devices, and your PC will then be mirrored on the Xbox.

Streaming Xbox One games to PC or mobile

You can also stream games the other way using the Xbox app, allowing you to play your Xbox games on a PC or mobile device. For mobiles, you can stream from both Xbox One consoles as well as Xbox Series X and S. For Windows, you can only stream from Xbox One consoles – for some reason Series consoles will not stream to Windows. On both mobiles and Windows, you can use a paired controller (such as an Xbox 360 Bluetooth controller).

You first need to go into your Xbox settings and make sure that Remote Play is enabled.

If you want to play on Windows, you can then launch the Xbox Console Companion app on Windows. In the left panel, click on Connect, which will search the local network for your Xbox, then select it from the list of detected Xboxes. Then click on the Stream button to see the Xbox screen mirrored on your PC.

If you want to play on an Android or iOS device, you'll need to install the Xbox app from the platform's app store. Then, launch the app and connect it to your account and Xbox. Tap on the connect button at the top right, and select Remote play on this device. You'll need to head back to your Xbox to authorise this, but once you do you'll your Xbox display will be mirrored on your mobile device and controllable with a paired controller.

Streaming PlayStation 4 and 5 games to PC or mobile

And finally we come to PlayStation, which, like Microsoft has a tool that will let you stream games from your PlayStation 4 or 5 console to be played on a PC or mobile.

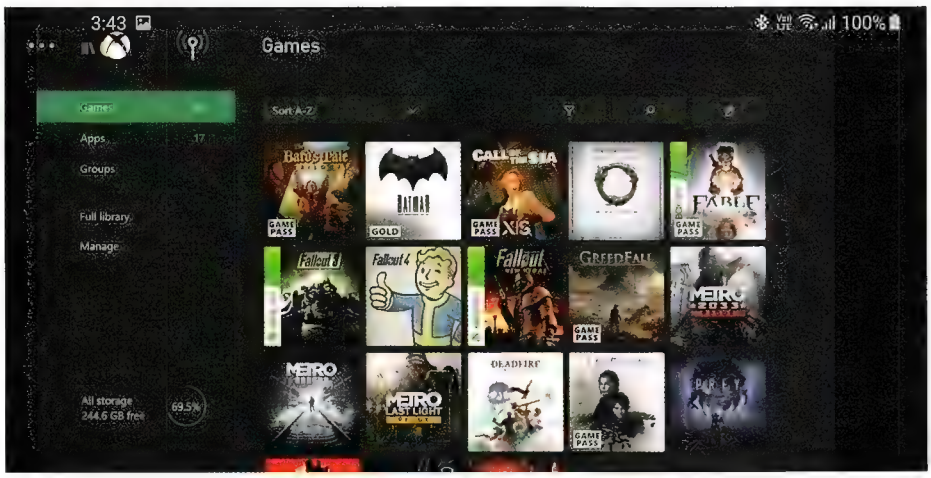
To start, on your PlayStation, you need to go to Settings > Remote Play Connection Settings and ensure it is enabled.

Once you've done that, leave the PlayStation running and download the PlayStation Remote Play App. It's available for Android on Google Play, for MacOS and iOS on the Apple App Store and for Windows 10 from **www.playstation.com/en-au/remote-play/**.

Launch the App, then sign into the PlayStation Network using the same credentials as on your PlayStation. Choose your console (PS4 or PS5), and the app will perform a search of your network and automatically connect to a device with a matching PSN login, mirroring the PlayStation screen on your PC or mobile.

You can control it with a controller paired to your PC or mobile, and it even allows for some mouse and keyboard controls (you can use the arrow keys in lieu of the D-Pad, for example). Enjoy your PlayStation games anywhere you want to play!

An Xbox Series X mirrored onto an Android display.



MAC

Notification Centre in Big Sur

Master widgets and notifications to keep yourself organised on your Mac.

IT WILL TAKE 10 minutes
YOU WILL LEARN How to use the Notification Centre and desktop widgets in macOS Big Sur
YOU'LL NEED macOS 11 or later

When Apple first launched macOS Big Sur in 2020, it overhauled the way the Notification Centre works on your Mac. Previously, this was divided between the Today view, which housed your tasks and widgets, and Notifications, which is where app alerts went if you dismissed them from your desktop. With macOS Big Sur, Apple merged the two sections into one.

This makes your notifications and widgets a lot more streamlined but may take some getting used to if you are accustomed to the two sections being separate. However, it also blends in a lot better to your Mac interface, both by improving the look of the whole Notification Centre and introducing things like notification stacks, which save space and declutter your desktop.

Widgets can be dragged into any position you want in the Notification Centre. Many widgets have different sizes displaying differing amounts of information.

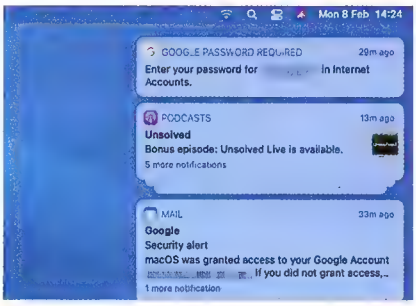
Working out widgets

Widgets have been in macOS for a while now, but they were given a new lease of life thanks to their introduction onto the iPhone and iPad with iOS 14 and iPadOS 14. On the Mac, you can now position widgets next to each other on a single row, add in different sizes of the same widget, and more.

This tutorial will take you through the basics of using Notification Centre and widgets in macOS Big Sur, as well as some tips on how to go a little deeper and customise this tool to suit you best. By the end, you should have a good grasp of all the new features and tools in macOS Big Sur's Notification Centre.

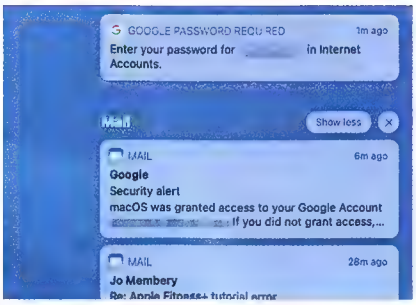
ALEX BLAKE

HOW TO Use Notification Centre and add widgets



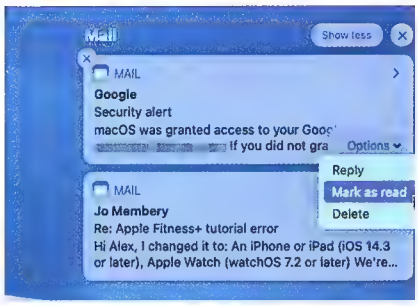
01 NOTIFICATION CENTRE BASICS

When a notification appears, swipe right on it to hide it. Click the time and date in the top-right corner to open Notification Centre. Here you can act on your alerts, including seeing more details, closing them, and more.



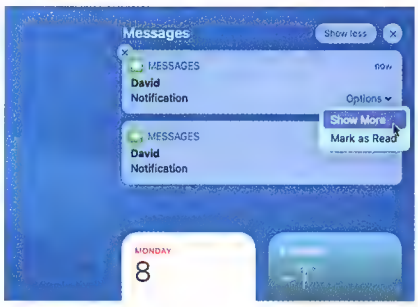
02 STACKED ALERTS

Multiple notifications from the same app are grouped in stacks. Click the top notification in a stack to expand it and see the others, or hide them by clicking Show Less. Clear (or Clear All) removes the stacked alerts.



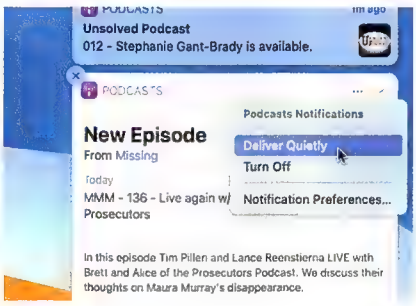
03 TAKE ACTION

Each notification has one or more options, such as snoozing an alarm or replying to a message. Hover over the notification to see the options (you might have to click a downward arrow to expand the options list).



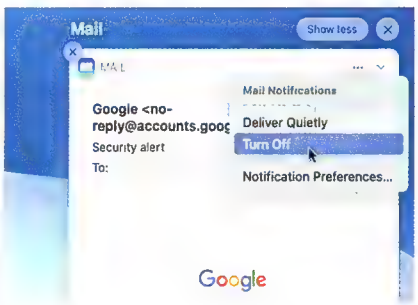
04 SEE MORE

Some notifications, such as those with content hidden by your settings, do not show everything on-screen. If a notification says 'See more', clicking this button will give you more options for responding to the alert.



05 DELIVER QUIETLY

To customise alert settings, click the '>' button, then '...' and choose Deliver Quietly (which sends alerts directly to Notification Centre) or Deliver Prominently. This plays a sound and shows a notification banner.



06 TURN OFF NOTIFICATIONS

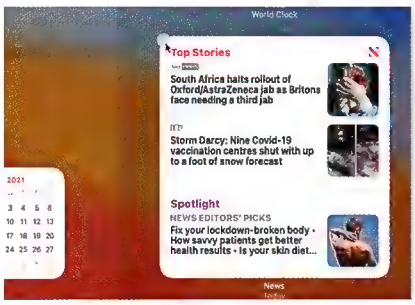
When adjusting notification settings, there is also a Turn Off button. As well as that, there is a button for Notification Preferences, which opens System Preferences on the Notifications pane (see 'Genius tip' on opposite page).

07 ADD A NEW WIDGET

The Notification Centre contains widgets. Click the time and date, then click Edit Widgets at the bottom. Choose an app on the left and select its size in the central column. Click the widget to add it to the sidebar.

08 ADJUST WIDGET ORDER

You can rearrange widgets already in the sidebar by clicking and dragging them to a new spot. When adding a new widget, you can drag it to wherever you want instead of automatically adding it to the bottom of the list.



09 REMOVE THE SURPLUS

When you are on the Edit Widget screen, hover over a widget in the sidebar and a minus '–' button appears. Click this to remove the widget. When you are finished, click Done at the bottom of the Notification Centre.

iOS

Offload your iOS files

Use USB sticks and memory cards to move files from your iPhone or iPad.

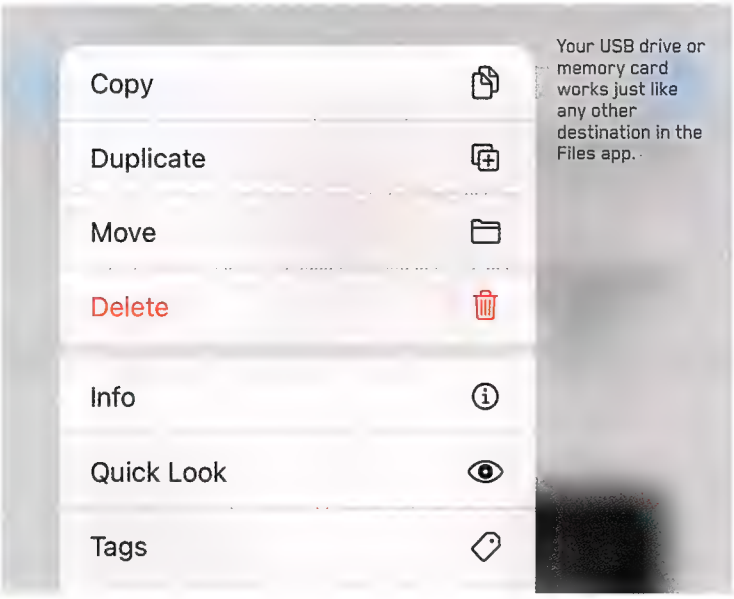
iPads and iPhones don't have expandable storage – but you can use external USB sticks and memory cards to transfer files or store things you don't need to keep on your device.

Things are easier if you own an iPad Air or iPad Pro equipped with USB-C, since you can connect USB-C sticks directly. However, often you'll need an adapter, especially when using a memory card, or an iPad or iPhone equipped with Lightning. In that case, to connect USB sticks, you'll need the Lightning to USB Camera Adapter or the Lightning to USB 3 Camera Adapter; to connect memory cards, the Lightning to SD Card Camera Reader or the USB-C to SD Card Camera Reader.

IT WILL TAKE 10 minutes

YOU WILL LEARN How to connect USB drives to your device

YOU'LL NEED Mac, iPad or iPhone, a suitable adapter and a power source



Your USB drive or memory card works just like any other destination in the Files app.

While USB sticks don't use as much power as external hard drives, they still need a certain amount in order to operate – and that maybe more power than your iPhone or iPad is willing to give them. In that circumstance, one of three things will happen: you'll get a pop-up saying 'Cannot use accessory... this accessory requires too much power'; the drive simply won't show up at all; or your iPhone or iPad will crash.

Power fix

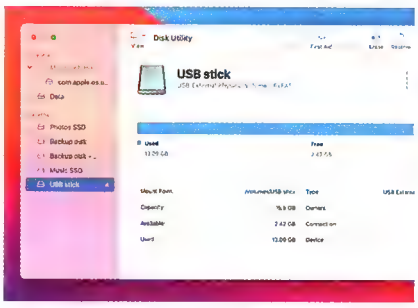
The solution is to use a powered USB hub that plugs into the mains, or the Lightning to USB 3 Camera Adapter with a power supply (other adapters don't have this option).

Using USB sticks with iPhones and iPads is really straightforward. It's a great way to transfer data that's too big for AirDrop when iCloud Drive isn't an option.

CARRIE MARSHALL

GENIUS TIP! Apple's USB adapters aren't just useful for external storage. You can also use them to connect USB hardware such as keyboards or instruments.

HOW TO Connect external items to iPhone or iPad

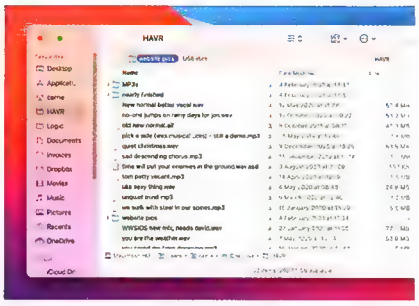


01 ERASE YOUR USB

If you're starting with a blank USB drive, it may not be blank: many manufacturers include utility apps. You can delete them manually or you can erase the drive in Disk Utility (it's in Applications > Utilities on your Mac).

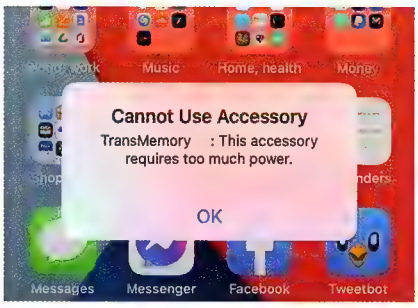
02 CHANGE THE FORMAT

Many USB sticks come formatted for Windows in FAT/ExFAT formats, and while they should work on your device it's prudent to format them as Mac OS Extended in Disk Utility unless you need to use the drive on non-Apple hardware.



03 DRAG YOUR DATA

You can save files to your drive or card from inside apps or you can drag and drop them in the Finder, as shown here. One of the quickest ways is to open the external device, then open a new tab for the folder you'll drag and drop from.

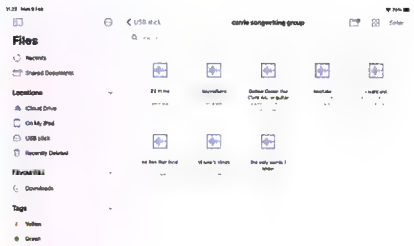


04 GET CONNECTED

Connect the adapter (if needed) to your Apple device and your USB stick or SD card to the adapter. If you're using a USB stick, you'll probably see this. USB drives need power to operate and your iPhone or iPad may not provide it.

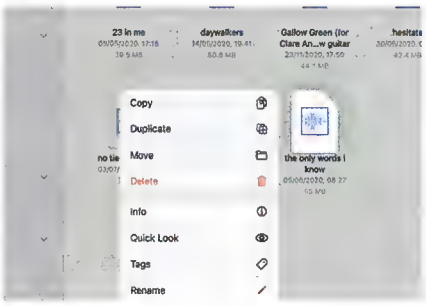
05 A HUB HELPS

If you have a mains-powered USB hub, you can put your USB stick in that then connect the hub to your adapter (as we've done here). If you open the Files app on your device, you should now see your USB device in the list of locations.



06 EXPLORE YOUR USB

Navigating around your external storage is no different from any other location: you can move from folder to folder, change the way files are displayed and so on. You can also use the search bar if there are lots of files in a folder.

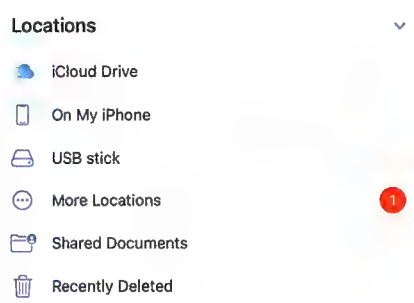


07 INTERACT WITH ITEMS

If you long-press a file icon, you'll see the context-sensitive menu shown here. This enables common file operations, such as duplicating and deleting, and you can also use it to rename or tag files and compress them.

08 ENJOY THE AUDIO

Provided your USB device is reasonably recent you should be able to play media directly from it without having to copy the file(s) to your iPad or iPhone first. High quality audio is usually fine but HD video can be a bit hit and miss.



09 ACCESS ON YOUR IPHONE

The Files app is on your iPhone too. It looks slightly different because of the smaller space but it works in exactly the same way: as with the iPad, it's just a matter of ensuring your USB device has a power source.

Terminal multiplexer

Shashank Sharma is enthralled by screen multiplexers, and Byobu presents an elegant and efficient approach to managing multiple windows.

Terminal multiplexers such as Tmux and Screen are part of the daily routine for most command-line warriors. These amazing tools can be used to run multiple shell sessions within a single terminal, or display more than one application in a single window. But these tasks are beyond the capabilities of regular terminal emulators, and you must use multiplexers.

Although multiplexers such as Screen have been around since the late 1980s, they aren't exactly welcoming to new users or CLI novices. Byobu aims to bridge the gap by providing a wrapper over multiplexers such as Screen and Tmux, as well as add some features to appeal to even new users.

Released under the GPLv3 Licence, Byobu started its journey as a wrapper for Screen, and was only available for Ubuntu. It has since adopted Tmux as the default underlying multiplexer and can be found in the software repositories of most popular distributions such as Debian, Fedora, Arch and Gentoo.

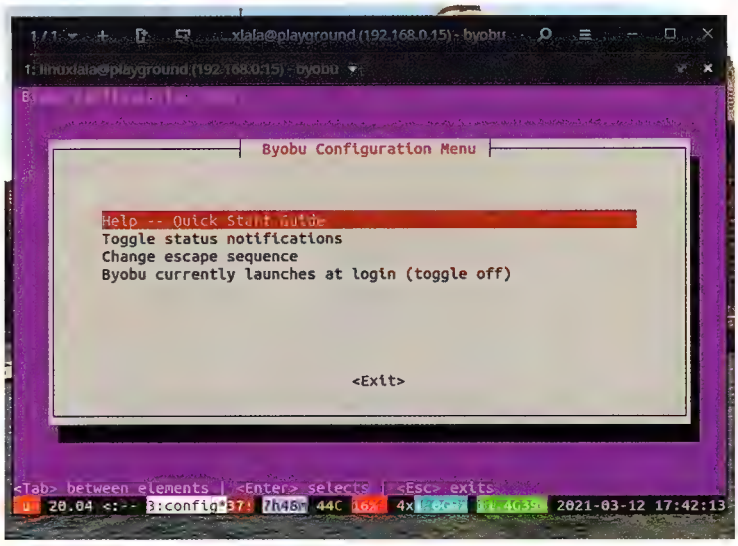
If you're running Debian or Ubuntu, or a derivative distribution, you can install Byobu with the `sudo apt install byobu` command. The `sudi dnf install byobu` command can similarly be used to install the project on RPM-based distributions. While it's possible to build it from source, the project itself recommends using your distro's package manager to install it.

Byobu is a Japanese word that refers to a folding, decorative, multi-panel screen typically used as room dividers. It's not a multiplexer itself, but an enhancement of the rather vanilla Screen and Tmux multiplexers. It aims to provide a simplified and more welcoming user interface to these robust utilities. Byobu also stands out from these tools because of its status bar, located at the bottom, which is used to display useful system information.

You can run Byobu by invoking the `byobu` command, without any command options. While Byobu defaults to Tmux as the underlying multiplexer, you can run the `byobu-screen` command instead if you prefer Screen. The latter command only works if you already have Screen installed. If not, make sure to install it using the package manager on your distro or Byobu will exit with an error.

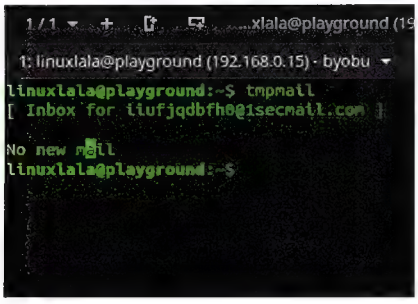
If you've never used a multiplexer such as Tmux or Screen, you should know that these tools enable you to easily split the terminal into different panes. Each of the different panes acts as an independent

QUICK TIP
If you find the default keybindings on Byobu interfering with some of the other command-line tools or applications that you prefer to use, you can toggle them on/off by pressing alt-F12.

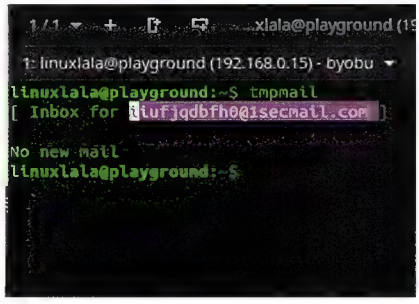


The Byobu configuration files are stored under the -/.byobu or the -/.config/byobu directory, depending on your distribution.

HOW TO Making sense of the copy mode



01 ENTER THE COPY MODE
You can enter the copy mode in any *Byobu* screen or split pane by pressing Alt-PgUp. You'll notice that you can now use the arrow keys to freely move through all the text on the current pane.



02 SELECT TEXT
To select text, first press Space and then use the arrow keys to select all the text you're interest in. You can select text across multiple lines. Next, press Enter to copy the text and exit the copy mode.

03 PASTE SELECTED TEXT
You can paste the selection made from one pane to another pane on the same window, or onto a different window. Switch to the target pane/window and then press Alt-Insert.

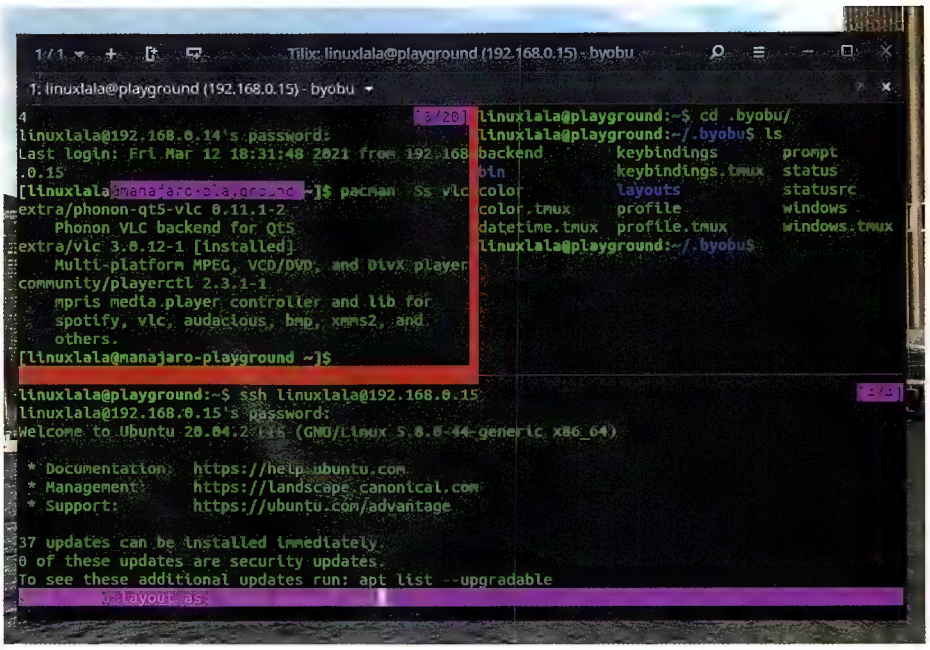
terminal. This makes it possible for you to perform myriad tasks from a single interface.

After starting Byobu, you'll be dropped to the shell prompt, with the status bar at the bottom of the screen showing a wealth of information. The status bar shows, from left to right, the name and version of your distribution, uptime, CPU and memory info, total disk space and current date and time.

Before anything else, press the F9 key to launch Byobu's Configuration menu. It has four entries. Your first step should be to look through the Quick Start Guide from this Configuration menu. This lists all the keybindings that you can use with Byobu, such as pressing Ctrl-F2 to split the screen vertically or Shift+arrow keys to navigate between the different split panes. The easy availability of the Quick Start guide is a useful addition by Byobu to multiplexers.

You can also use the Configuration Menu to change the information displayed in the status bar, by selecting Toggle Status Notifications and pressing Enter. You can then select the info you wish to be displayed in the status bar. In addition to the information displayed by default, you can also make visible the IP address, battery status and more.

You'll figure out the different keybindings with time, but here are some of the most useful ones to help you get started:



We've used the copy mode to select text in the first pane, and also decided to save the spilt layout for future use by pressing Ctrl-Shift-F8.

"Although multiplexers such as Screen have been around since the late 1980s, they aren't exactly welcoming to new users or CLI novices. Byobu aims to bridge the gap by providing a wrapper over multiplexers such as Screen and Tmux, as well as add some features to appeal to even new users."

Useful Byobu keybindings

Keybinding	Function
F2	Launch a new window
F3	Navigate between the different windows
CTRL-F2	Create a vertical split on the current window
SHIFT-F2	Create a horizontal split on the current window
SHIFT-ARROW KEYS	Navigate between the splits on the current window
F6	Exit Byobu, but keep it running in the background
CTRL-F6	Close the selected window/pane
SHIFT-F8	Toggle between the layout grid templates
SHIFT-F12	Toggle on/off Byobu keybindings
ALT-F12	Toggle on/off mouse support
CTRL-SHIFT-F5	Toggle through random background colours for the status bar

Although it's fairly easy to navigate between the different windows and split panes using the keybindings, you can also enable mouse support within Byobu. Once done, you can left-click to select the different panes and also drag-and-drop to increase or decrease the size of any pane.

You can exit a Byobu session, but still maintain the layout of the different panes/windows. This is especially useful because it saves time having to relaunch all the different panes and windows that you require. To exit Byobu, but leave the session running in the background such that you can return to it anytime you want, press F6. This detaches the Byobu session, but keeps it quietly active in the background while you tackle more pressing tasks.

Advanced usage

There's still more that you can do with Byobu, especially if you spend a lot of time on the terminal. If your Byobu screens and panes produce a lot of output, you can search through it all using Byobu's scrollback mode.

Press F7 to enter the scrollback mode. You can now search backwards through the selected pane/window by typing `?`. You'll notice that at the bottom of the screen, just above the status bar, a new (search up) bar appears. Type the text you wish to look up, and hit Enter. Byobu will automatically highlight all matches.

The scrollback mode defaults to searching downwards, but you can also confirm this by pressing `/` after entering scrollback mode. The bar at the bottom now reads (search down).

Once you have a split layout that you enjoy working with, you can save it for future use by pressing Ctrl-Shift-F8. You'll be prompted to provide a name for the layout. You can save different layouts, for different tasks, each with differently sized split panes. You can display a list of all saved layouts by running the `byobu-layout list` command. You can then restore a saved layout by running the `byobu-layout restore <name>` command. ■

Escape from the evil space squids!

Captain Les Pounder of the USS Rentaprize has to evade the clutches of the evil space squids, but can he do the maths to escape the planet?

Block-based coding is a great way to introduce the concepts of coding, via an easy-to-understand mechanism. Blocks of code are stacked to create a flow, and if we encounter a mistake, we can easily pull the code apart to "debug".

Scratch is a popular block editor and in this tutorial we'll create a space escape game, where our rocket is trapped on an alien world and we need to calculate the correct thrust for lift-off. If we get it wrong more than 10 times then the evil space squids will get us.

Scratch 3 should come pre-installed on your Raspberry Pi OS image, but if it's missing it can be installed from the main menu, under Preferences> Recommended Software. Scratch 3 is found in the Programming category; place a tick in the box and click Apply to install. Once installed,Scratch 3 can be found in the main menu under Programming.

Open Scratch 3 . Before we write any code, let's understand the interface. On the left are a series of colour-coded, categorised blocks of code. These blocks fall under categories that identify what they do: Motion to move a sprite, Looks to change their appearance, Control to create the logic for our code. The blocks are dragged into the centre area and then assembled into a project. In the top right of the screen we have the Stage – this is where our code will run, we see things move and we can interact with the code. Finally, in the bottom right is where all of the sprites, the characters in our game and the backdrop of our stage can be edited.

We'll start in the bottom right of the screen. The default sprite is Scratch the cat, but for this game we can delete the cat by clicking the trashcan icon in the top right of the sprite. If you look to the bottom right there's a blue cat icon. Click this icon to add a new sprite. Search for rocket to use the sprite. Repeat this process and search for a sprite to act as our alien – we chose a squid. Just to the right is a blue icon that changes the look of the stage, a backdrop. Click the icon and select a space-themed backdrop.

Make sure that your rocket sprite is selected, left click the sprite. We'll start writing the code for our game. First we go to Events and drag `When Green Flag Clicked` . This will start our game when the green flag above the stage is clicked. Drag the rocket sprite so that it's resting on the planet. Go to Motion and drag the `Go to x: y:` block so that it connects with the previous. Now when the game starts, the rocket returns to the planet.

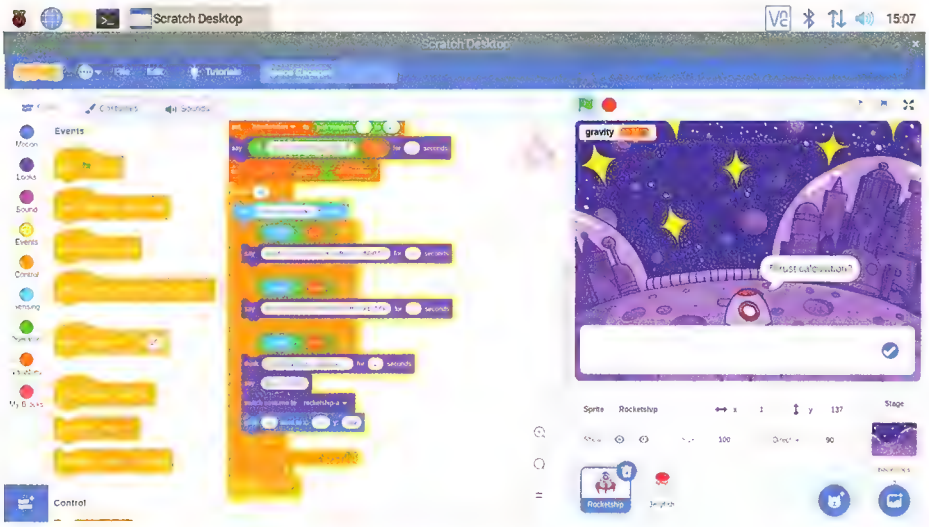
The next three blocks are all from Looks. The first is `Switch costume` – drag this and connect to the previous blocks. Change the costume to `rocketship-e` . Now drag two `Say ___ for 2 seconds` blocks and connect to the previous. In the first Say block, we tell the player that aliens are coming; in the next block we instruct the player to calculate the thrust for take-off.

YOU'LL NEED
- Any Raspberry Pi
- Raspberry Pi OS
- Breadboard
- LED
- 330 Ohm resistor (Orange-Orange-Brown-Gold)
- 2 x female-to-male jumper wires
- Code: **https://github.com/lesp/LXF275-PiUser-SpaceEscape/archive/main.zip**

Feeling gravity's pull

Next we go to Variables and create three variables. The first is called gravity. Drag `Set gravity to 0` and connect to the previous block. From operators drag the `Pick random` block and place it over the zero of the Set block. Change the numbers to be from `one` to `20`. Create another variable, Acceleration and repeat `Pick random` but keep the numbers as `one` to `10`. So now we have two variables that will generate random numbers for our game. The third variable is called `force` and for now we just need to create it – we'll use it later.

We need to give the player a clue to escape the planet. For this we use another `Say` block, but this time we go to Operators and drag a `Join` block over the text of `Say` . In the first blank of `Join` we say `Sensors show the gravity is` , and in the second we drag the gravity block from Variables. This block updates with a random value each time the game starts. Next we drag `Set force` from Variables and connect it to the previous. In our case force is a calculation, so we need to go to Operators and drag `__ * __` into the Set block. Then drag the gravity and acceleration blocks from Variables so that `force = gravity * acceleration`. Note we only



Our finished game is a colourful and engaging way to test number skills and logic, but sadly it won't get us into outer space.

want the gravity variable visible. To turn off the others click the tickbox next to their name in Variables.

Ten chances and counting...

So we have the data now we need to code the game mechanism. For this we need to give the player 10 chances for take-off. From Control drag repeat 10 into the coding area and connect to the previous blocks. We now need a means for the player to make their guess – for this we go to Sensing and drag the Ask __ and wait block into the repeat 10 loop. Change the text to read Thrust calculation? . Each time the player guess, their answer is stored in a special variable called answer which is located in the Sensing section.

Next drag three if blocks and place them underneath the question, inside the repeat 10 loop. Ensure they're stacked upon one another and not inside each other. Each if is a question to check the player's guess against the answer stored in the force variable. The if statement has a hexagon-shaped box, in which we're going to drag a block that compares two values. Found in Operators, we first drag __ > 50 and place it in the first if hexagon. From Sensing we drag the answer block and place in the first blank. Then from Variables we drag force and place that over the 50 . So this statement checks if the user's answer is greater than the force needed to escape. If that is correct (true) inside that if statement we place a say block from Looks and we change the text to alert the player that there's too much thrust and we must abort.

For the next if statement we repeat the same process, but use a __ < 50 and change the text to say that there's insufficient thrust for take-off. The final if statement checks to see if the user's guess is the same as the answer stored in the force variable. This uses the __ = 50 block from Operators and the same answer and force blocks as before. If this statement is correct, we go to Looks and drag the think block into the if statement. We alter the text to Checking thrust calculations... , then go back to Looks, drag Say and alter the text to BLAST OFF .

Again, back to Looks. We chose switch the costume to rocketship-a , which changes the sprite so that we have a plume of fire thrusting the rocket upwards. To give the rocket motion, drag the rocket to the top centre of the screen, so that only the plume of fire is visible. Go to Motion, and drag glide _ secs to x: _ y: _ into the code. The x and y values will be populated by the current position of the rocket. The final block inside this if statement is Stop all and it's found in Control.

The final block in this game is outside the repeat 10 and if statements. From Events we drag broadcast and change the message to read attack . This broadcast will signal our alien sprite.

Click the alien to start writing code for that sprite. The first block is from Events and it's When I receive __ , drag this and change it to attack . This means the code will run when the player loses. From control drag a repeat 10 block and inside place the following blocks from Looks, Show , change color effect by 25 , next costume and change size by 10 . Lastly from Control place wait 1 seconds inside the loop. Change the duration to 0.5 seconds. Our last piece of code uses When Green Flag Clicked from Events, and from Looks we use hide to make sure the alien hides until the end!

Click the Green Flag to start the game, and try to escape from the evil space squids!

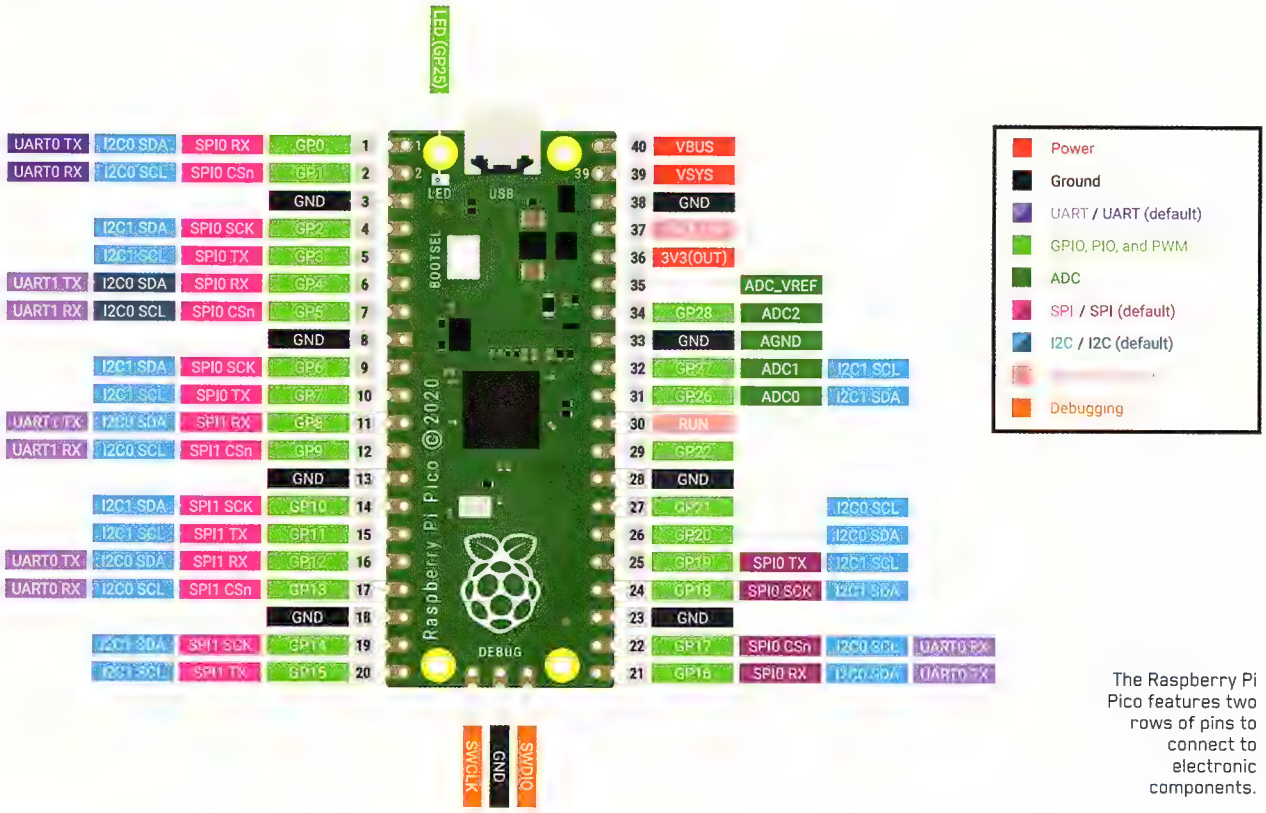
Sprites are characters in a game. In our case the rocket and squid alien are sprites. Each sprite can have its own programming and they can talk to one another.

If conditional statements are questions in code. They check to see if something is true, and if so then a section of code is activated.

Scratch 3.0 and the GPIO

Scratch is much more than just for making games. We can also use the GPIO from Scratch 3.0. In the bottom left of the screen there's a blue folder icon. Click this to open the Extensions menu. Scroll down to Raspberry Pi GPIO and click to install. This adds another set of blocks to the menu. Next we need to connect an LED, 330 Ohm resistor to a breadboard, and using two male-to-female jumper wires connect to the GPIO (see download for a detailed diagram).

In Scratch go to Events and drag When Green Flag Clicked into the coding area. Then from Control drag repeat 10 . From the Raspberry Pi GPIO drag set gpio 0 to output high and place it inside the loop. Change the 0 to 17 because we're using GPIO 17. Now drag wait 1 seconds from Control and change to 0.1 seconds. Drag another set gpio 0 to output high and change 0 to 17, and high to low. Place another wait 1 seconds into the loop. Change the duration to 0.1 again. When you're ready, click the green flag to start the code and you'll see a flashing LED.



The Raspberry Pi Pico features two rows of pins to connect to electronic components.

OPEN SOURCE MASTERCLASS

Raspberry Pi Pico: the Raspberry Pi meets Arduino

Meet the new makerboard and chip from Raspberry Pi that takes the famed single-board computer to a whole new (and lower) level. Darren Yates explains.

The arrival of the Raspberry Pi back in 2012 revolutionised computing. All of a sudden, we had this single-core single-board computer that cost less than $50. It wasn't the only option, with a number of Android TV sticks also hitting the market for around the same price, but it was the Raspberry Pi that turned computing into a commodity item. However, prior to the Pi, another revolution had sparked up in the electronics engineering world – Arduino created a new common platform for single-function or 'embedded' applications, no operating system required.

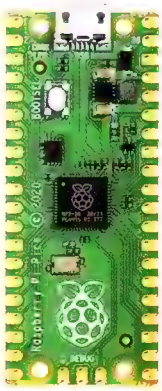
For the last ten years, both Raspberry Pi and Arduino have built their respective ecosystems. But now in 2021, the new Raspberry Pi Pico microcontroller board and the Arduino IDE allow these two ecosystems to collide. This month, we look at the Pico and why it's an important evolution in the Raspberry Pi ecosystem.

What is the Raspberry Pi Pico?

The Pico is a small circuit board about the size of a USB stick with two rows of connecting pins on either side. It's designed to slot into a reusable circuit builder called a 'breadboard' that allows you to create your own electronic circuits. The Pico itself features a special self-contained microprocessor called a 'microcontroller'.

This microcontroller on the Pico is the new RP2040 and features a dual-core 32-bit ARM Cortex M0+ design running at up to 133MHz, with 264KB of RAM and 2MB of on-board flash storage.

Now if you're thinking these specs sound very 1990s and much less than previous Raspberry Pi boards, hold your horses for a sec.



The Pico is about the size of a USB stick with a new RP2040 microcontroller chip.

The Pico is a completely different beast to previous Pi boards. Rather than being a general-purpose single-board computer requiring operating system and external storage, the Pico is designed for lower-level or 'embedded' specific-function applications. The Pico's microcontroller chip has its own RAM and storage and doesn't need an operating system. Instead, it runs your compiled code directly on the chip's CPU core, which gives you two benefits. First, running your code directly means there's no need for an operating system, which greatly reduces the amount of RAM and storage you need to perform a specific task. But second, since your code runs right on the 'bare metal' (the chip itself with no operating system layer), it runs much more efficiently – you can still achieve complex tasks, but with lower (and more power-efficient) clock speeds.

What can you do with it?

Whereas a computer is meant to interface with monitors, storage, keyboards and USB devices, microcontrollers in general (and the Pico in particular) are designed to connect directly to electronic components – resistors, capacitors, transistors, sensors, motors, buzzers, LEDs. They enable you to interface with the real world – measure temperatures, actuate motors, light LEDs, sound buzzers. Microcontrollers provide more limited computing power but at very low cost.

If you followed our Arduino series in *APC* a few years ago, we used Arduino microcontrollers to build robots, a working Enigma Cipher Machine and even a stereo digital audio recorder. Think of it like this – computers are very good at many things; microcontrollers are exceptional at one thing, whatever that one thing is you want to make.

More recent developments now even bring machine-learning to microcontrollers and the Pico is no exception, thanks to efforts such as TinyML. With machine-learning, you can use a Pico to detect different objects from a camera sensor, for example, or even do speech recognition.

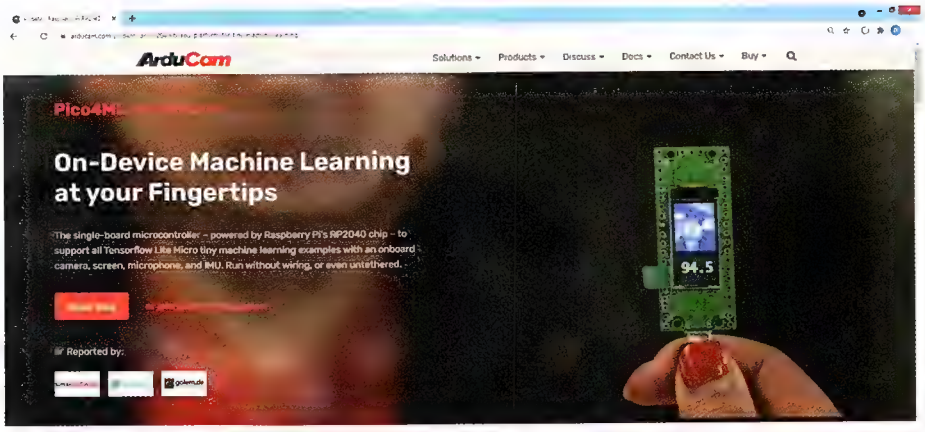
How do you use it?

Microcontrollers like the Pico are where software meets hardware – and you get to design both. While you plug in your LEDs, resistors and other components to make a circuit, you also write the software that makes the microcontroller do something with those components.

The Pico supports a number of programming languages – you can code it with Micropython and you can even hook it up to the Arduino integrated development environment (IDE) and use a simplified version of C++.

If you remember your high-school coding lessons, you may have coded a program that takes user input from the keyboard, for example if the 'y' or 'n' keys are pressed. By contrast, with microcontrollers, you can check whether one of the digital input/output (I/O) pins is connected to the electrical-high or low voltage lines. This might be if a doorbell pushbutton is pressed.

You can also measure the analog value of a light-dependent resistor or temperature sensor using the analog-to-digital converter. The ADC converts analog voltage into a digital number that you can use to perform a task. For example, if the ADC shows the resistance level of an LDR has risen above a certain level (meaning the light-level has dropped), you can activate an output pin that has an LED connected to it and create an automated light switch.



An RP2040 Based TinyML Dev Board

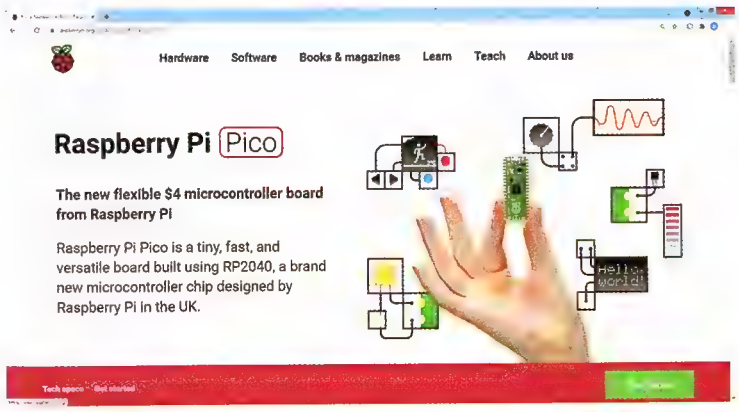
The Pico's RP2040 chip is sophisticated enough to handle machine-learning tasks.

Not perfect, but looks a solid effort

At time of writing, local Australian supply of the Pico was still a bit tight, with at least one retailer limiting sales to one per customer. However, given its $6 price tag, expect demand to continue. The interoperability of the Pico with the Arduino IDE, combined with the ability to code in C++ or Python will ensure the Pico is used in a wide range of applications.

That said, I wouldn't call the Pico 'perfect'. For example, you only get one analog-to-digital converter (ADC), its sample rate is only 500-kilosamples-per-second (500kSps) and it doesn't have a dedicated ADC voltage reference. There's also no on-board wireless connectivity and no digital-to-analog converter (DAC). As an alternative, popular boards based on the STM32F103 microcontroller sell on Ebay for around $8 and include two 12-bit ADCs with one-mega-sample-per-second (1000kSps) sample rates. More recent Arduino boards offer Bluetooth and WiFi wireless connectivity.

The point is there are many different microcontroller boards on the market, each with their own mix of processing power and built-in peripheral features. The Raspberry Pi Pico is now another option in this increasingly crowded market, albeit an instant market heavyweight thanks to its huge Raspberry Pi community. What's more, for those who have never stepped outside of the Raspberry Pi ecosystem, the Pico is a step into the broader world of embedded electronics engineering, where appliances and machines are powered by microcontrollers, everything from phones to dishwashers, TVs to cars and the Internet of Things. If the Pico introduces people to this fascinating world of electronics, more's the better.



The Pico is backed by the Raspberry Pi foundation and its huge community resources.

This black model was the most common worldwide, but white models were available in Japan, and red models in Spain.

© Wikipedia

MACHINE OF THE MONTH

Sega SC-3000 (1983)

A microcomputer? From Sega? John Knight investigates.

Before its famous consoles, Sega briefly experimented with home computing. Until the 1980s, Sega's income came mostly from arcade machines, but the booming market in home gaming and home computing was simply too big to ignore, and it was time for Sega to test the market.

Sega was unsure whether to put its weight behind home computers or simple game consoles. The company decided to hedge its bets with both: a console, the SG-1000, and a microcomputer, the SC-3000. Each model is based on the same underlying hardware.

These machines provide an excellent way to explore Sega's earlier software before its worldwide console-gaming success. And the SC-3000 provides a glimpse of what Sega would have been like had it continued down the path of home computing.

However, the SC-3000 never had a North American release, and even in its best markets, machines are rare nowadays. Emulation is now the only real option for most people, so allow us to show you the easiest ways to emulate the SC-3000 on your own PC after we take you through a brief tour of its history.

Release

Launching in July 1983, the SC-3000 had a limited release worldwide, shipping to Japan, France, Italy, Finland, Spain, South Africa, Australia, and New Zealand. Its launch price of 29,800 Yen was substantially cheaper than the dominant Commodore 64, but with competitive levels of performance.

Hardware-wise, the SC-3000 is essentially just an SG-1000 console with a keyboard, and is entirely compatible with SG-1000 games. The CPU is an NEC D780C-1 (a clone of the Zilog Z80A) running at 3.58MHz, and its video coprocessor can display 32 single-colour sprites on screen.

The SC-3000 was built using off-the-shelf parts and is close to the MSX standard – many MSX titles were Sega ports. However, SC-3000 and MSX software is not cross-compatible. The Sega has a superior sound chip, no built-in operating system, and only 2KB of system RAM. Most memory was actually supplied on software cartridges, and the machine doesn't function without a cartridge inserted.

Like the ZX Spectrum, initial models came with cheap rubber keyboards, and entire BASIC commands were assigned to single keys. The more expensive SC-3000H model soon followed with a proper keyboard.

Exerion (1983) features a cool faux-3D moving backdrop and provides a fresh take on *Galaga*-style gameplay.

© Exerion

Software

Most software comes on ROM cartridges, the Sega My Card format, or on cassette; 3.5-inch floppy support was available via the SF-7000 expansion box, which also added 64KB of RAM, but these were very expensive, and disk-based software isn't common.

Beyond Sega's official titles,

SPECIFICATIONS **CPU:** NEC D780C-1 @ 3.58MHz, **VRAM:** 16KB, **RAM:** 2KB embedded, expandable up to 64KB , by cartridges or add-ons, **Launch price:** ¥29,800, **Graphics:** 16 colours @ 256x192, 32 on-screen sprites via Texas Instruments TMS9929A coprocessor, **Sound:** Texas Instruments SN-76489AN PCM, **Storage:** ROM cartridge, Sega My Card, cassette, 3.5-inch floppy, **OS:** None, Sega BASIC available on cartridge, **Released:** July 1983, **Production:** 1983–1985, **Worldwide sales:** Unknown

most other applications were tape-based releases from Australia and New Zealand.

Gaming-wise, the experience is similar to the MSX, with a slightly higher standard of presentation. The sound is also better, with a very distinctive crystal-like tone. Most games use a two-button joystick layout.

To pick some highlights, *Star Jacker* is an innovative vertical shooter; *Elevator Action* is a fan favorite; *Girl's Garden* is a weird gem from the creator of *Sonic the Hedgehog*; and *C-So!* has a crazy platforming mechanic.

Legacy

Despite having a reputation as a commercial flop (Sega's sales figures were only in the thousands, and were dwarfed by Nintendo's Famicom), the SC-3000 and SG-1000 outsold Sega's projected sales figures significantly. Between the SC-3000 and the SG-1000, the SC-3000 microcomputer sold more units than its console sibling.

While the SC-3000 had moderate sales in all of its launch countries, most sales were either in Japan, or Australia and New Zealand, where it still has a cult following today.

However, Sega recognised the machine's weakness toward business applications and felt further machines wouldn't compete in an already saturated home computer market, so pulled out in 1985.

Although Sega mostly abandoned home computing after the SC-3000, the successful production run inspired Sega to keep producing game consoles, leading to 1985's Mark III console – or Sega Master System, outside Japan.

YOU'LL NEED

BINARIES

Binaries for Windows x86 are available online (**www.smspower.org/meka**), along with binaries for older Linux and DOS versions. Linux users may want to run newer Windows binaries through Wine.

© Sega

Master System classic *The Ninja* was the SC-3000's *Ninja Princess* (1986) originally, and is much loved by Sega fans.

Emulation

If you only want to play SG-1000 console games, the easiest option is to use Kega Fusion (**www.carpeludum.com/kega-fusion**), which supports Windows, Linux, and MacOS. The interface is intuitive and fairly self-explanatory, but to load SG-1000 games, just act as though you are loading a Master System game by clicking "File > Load MasterSystem ROM."

If you specifically want to emulate the SC-3000 – especially if you want to use keyboard inputs and BASIC – we recommend MEKA (**www.smspower.org/meka**). MEKA also runs Taiwanese titles, while Kega Fusion does not. Officially, MEKA supports Windows and Linux, with older versions also running on DOS. However, the Linux version needs to be compiled from source.

The MEKA project is seeking a Linux maintainer to provide pre-made binaries (if you feel up to the task!), but for now, Linux users may want to use the Windows binary through Wine instead.

The website provides a ZIP file with Windows binaries. Download and extract the ZIP file, then open the new folder. The executable is called mekaw.exe, and may require you to allow Administrator privileges, depending on your installation. MEKA doesn't come with a self-installer, so you may want to make a desktop shortcut to the executable.

Getting started

On your first run, there is a setup window where you can choose your video driver, resolution, and language settings. Click "OK" and you're taken to MEKA's main screen. To load a normal game ROM, you can either use the Load ROM window, which is enabled by default, or from the top menu, click "Main > Load ROM." This opens a file browser. Select your ROM file and click "Load."

Your game should now load within the MEKA window. Press Alt-Enter to switch to full-screen mode. Press Escape to switch between the full game window or a small window within the MEKA home screen.

By default, MEKA has its controls set to emulate a Master System controller on the keyboard. Player 1's controls are set to the arrow keys for movement, Z and X for Button 1 and 2, Space for Pause/Start, and Backspace to reset the emulated machine.

Loading basic

Getting BASIC to function is slightly more difficult, however, because you need to enable keyboard emulation. You also need to find a BASIC cartridge ROM, because the Sega didn't come with a built-in operating system.

To get started, enable keyboard emulation by either choosing "Inputs > Sega Keyboard" from the top menu, or by pressing Ctrl-F9. You'll see a Japanese keyboard appear at the bottom of the screen. Now load the BASIC cartridge like any other ROM, and MEKA should accept keyboard inputs.

In the likely event that you can't find the right key to press, you can press Escape to return to the home screen and examine the visual Japanese keyboard for keystroke references. ■

Find software

The official Sega software collection isn't large, and full collections of Sega ROM cartridges are on **Archive.org** for both SG-1000 and SC-3000 software. For anyone willing to get stuck in and learn how to program the machine, issues of New Zealand's Sega Computer Magazine are also available at **Archive.org**.

Anyone wanting to keep an eye out for new SC-3000 developments should check out **www.sc-3000.com**. For the more hardcore users (and perhaps even actual SC-3000 owners), **http://sc3000-multicart.com** has new cartridge-based hardware available for the machine, as well as tape audio archives.

A new *TimeSplitters* game is coming

DEVELOPMENT HASN'T STARTED, SO IT'S PROBABLY A WHILE OFF.

A new *TimeSplitters* game will enter development "in the coming months," publisher Deep Silver has confirmed. Not only that, but founding studio Free Radical Design has been reformed to develop it, with founders David Doak and Steve Ellis confirmed to be involved.

TimeSplitters is a beloved console FPS first released in 2000. It had a lot in common with Rare's classic Nintendo 64 shooters – *Goldeneye 007* and *Perfect Dark* – not least because Doak had a hand in creating those games, too. The last official *TimeSplitters* game released in 2005, though a fan project called *TimeSplitters Rewind* is still in development.

As for this new, fourth installment, Deep Silver has said very little about it. Free Radical Design is currently "concentrating on building the studio" which will be based in Nottingham – just like it used to be before it originally closed in 2014.

GAMING NEWS

Following ban, *Disco Elysium* is now available in Australia

Upon review, the Australian Classification Board amended to an R18+.

Nearly two months after its release in the rest of the world, *Disco Elysium: The Final Cut* is now available in Australia for PS5 and PS4. The delayed release comes after the RPG was initially refused classification in Australia, meaning it was effectively banned in the country. Despite its "ban" however, versions of the game for PC have remained available throughout the ban period.

The game now carries an R18+ rating in Australia and costs $59.95 on the PlayStation Store. The main sticking point for the Australian Classification Board was the game's depiction of drug use, among other things. When the board revised its rating in May, it admitted that *Disco Elysium* offers "sufficient disincentives to drug use to enable it to be accommodated within the R 18+ classification".

Now that the ban has been overturned, it clears the way for the eventual *Disco Elysium* Switch port – and it also means console-bound Australians will be ready for the forthcoming *Disco Elysium* TV show.

Netflix wants to make games

After some dabbling, the company wants a bigger piece of the interactive pie.

Netflix is reportedly looking to expand its videogames interests, according to a May report by The Information. This move will expand upon the company's existing "interactive entertainment" initiatives, such as *Black Mirror: Bandersnatch*, and collaborations with third-party developers for projects like *Stranger Things 3: The Game*.

According to the same report, Netflix is approaching high profile talent in the games industry, and is interested in implementing an Apple Arcade style approach to games. In a statement provided to *Techradar*, the company didn't outright dispute the report. "[Netflix] Members... enjoy engaging more directly with stories they love – through interactive shows like *Bandersnatch* and *You v. Wild*, or games based on *Stranger Things*, *La Casa de Papel* and *To All the Boys*," a spokesperson said, "so we're excited to do more with interactive entertainment."

Gears of War studio confirms it's not working on a *Star Wars* title

The Coalition recently revealed that all future projects will be developed on Unreal Engine 5.

Gears of War studio The Coalition is shutting down rumours that it's developing a new *Star Wars* title. With the news that The Coalition is shifting development of all future projects to Unreal Engine 5, a recent rumour from GamesBeat's Jeff Grubb naturally made its way into the Reddit conversation, but the *Gears* studio wasn't having any of it. In a reply to a comment invoking the rumour, *Gears of War* community manager TC Kilo, in no uncertain terms, squashed it.

"Just to clarify regarding the *Star Wars* thing," reads the response from The Coalition. "We are not working on any such title. We have nothing else to announce at this time."

In announcing that The Coalition is moving to a next-gen development engine, the studio also made sure to temper expectations about new game announcements more generally. "Shifting to a new engine is a big undertaking, so we want to be clear that we will not be announcing any new projects or titles for some time."

Battlefield 6 reveal set for June, EA confirms

Expect the first proper *Battlefield 6* trailer real soon now.

As spotted by Battlefield News, EA CEO Andrew Wilson confirmed the June reveal during the company's earnings call on Tuesday. A specific date wasn't mentioned, but more info drops were teased for the remainder of the summer.

It's not like there were a ton of other ways to perceive the tease we reported on below, but it's good to know for sure that we won't be waiting much longer to finally witness *Battlefield 6*'s introduction.

EA and DICE teased back in April that the next *Battlefield* game would get its long-awaited proper reveal "soon," along with confirming that, whatever it is, it will be headed to PC and new-gen consoles this year. Not very specific, right? Well, today it sent out another Tweet with the observation that both the words "June" and "boom" rhyme with "soon." Hm. Hmm.

EA hasn't announced its own official E3 2021 event yet, but that's hardly a surprise since it has done its own EA-adjacent event with EA Play for the last few years anyway.

EA to give open world adventure genre another red hot go

AFTER A LOT OF MISFIRES, IT HAS RECRUITED FORMER MONOLITH PRODUCTIONS TALENT.

Electronic Arts has founded a new as-yet unnamed studio headed by former Monolith Productions VP Kevin Stephens. Like Monolith Productions' best known work, including the two most recent Middle-earth games, the new studio will work on an open world adventure game.

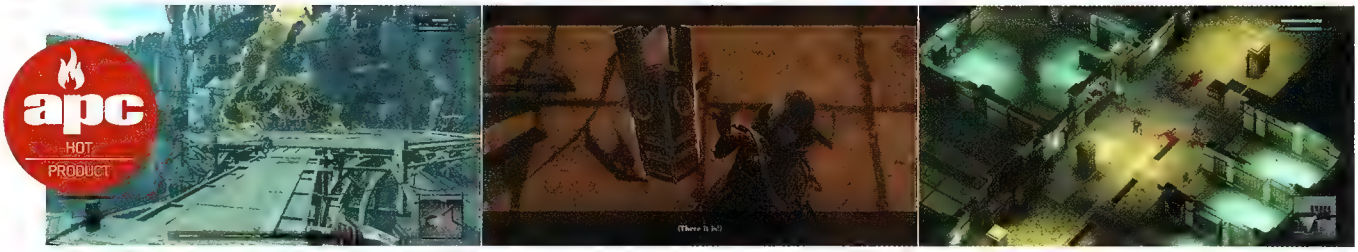
According to senior EA head Samantha Ryan, the success of *Star Wars Jedi: Fallen Order* can be credited for EA's interest in the "action-adventure space" - despite cancelling a *Star Wars* open world action-adventure only a matter of years ago. No word as yet on whether the new studio will be working on existing IP or something new.

Fortnite PvE survival mode Daybreak referenced in latest patch

Files datamined from today's 16.40 patch aren't the first to reference an "open world simulation sandbox." Noted *Fortnite* leaker Hypex recently tweeted out what seem to be images of the new map and some of the props on the island. Leaked documents from the Apple vs Epic trial seemingly connect the images with the upcoming Daybreak mode.

Resident Evil Village is the fastest-selling game in the series

Resident Evil Village sales have surpassed three million in four days, Capcom has announced. This puts *Resident Evil Village* in the joint-first position for the best game launch in the series. Back in 2012, *Resident Evil 6* also managed to sell three million units in four total days, but *Village* is well ahead of both *Resident Evil 2 Remake*'s launch, and *Resident Evil 3 Remake*'s debut ■



$89.95 | PC, PS4, XB1 | nier.square-enix-games.com/en-us

Nier Replicant

A welcome second chance for a singular action-RPG.

If *Nier* was characterised by desperation, *Nier Replicant* is an act of love. Created by developer Toylogic and publisher Square Enix with the direct involvement of Taro and his regular band of collaborators, this remaster feels like an attempt to make good on the ideas and promises of that original game. After its sequel *Nier Automata* became an unlikely hit in 2017, the team is betting that now is the right time to reintroduce broader audiences to the charms of the original game. Maybe this time they'll be more receptive.

I honestly don't know if they will: even in its remastered form, *Nier* remains a singular and at times tedious game, a piece of art eager to try everything and constantly seeking out the hardest notes to hit. But it's one of the most memorable games I've played, and the remaster ups its greatness in just about every way. Taking place literally thousands of years before that story, it's set in a post-apocalypse that's swung right back around to pastoral fantasy, following a boy and his sister in a world of magic diseases, monsters, and at least one talking book. As that boy, you'll be questing around a dark fantasy world while trying to cure your sister of a terrible disease, joining up with some of the best outcasts in gaming.

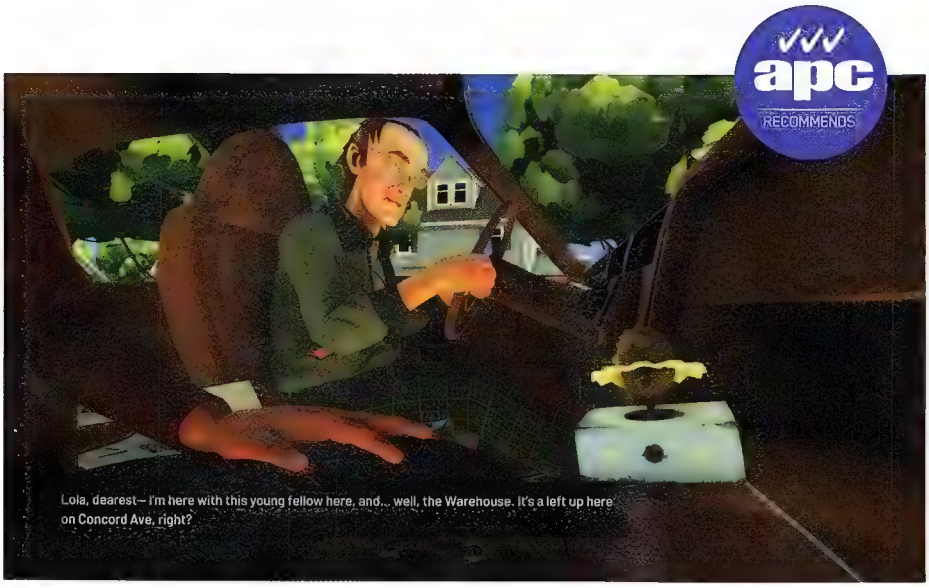
The game plays out like a sort of dark pastiche of standard fantasy adventure games like *The Legend of Zelda*, delighting in videogame conventions while also subverting them and turning to deeper thematic territory, meditating on violence, human cruelty, and what it means to persist in a world that wants you dead and is probably dying itself.

You'll be spending most of your time running around lush fields and dank dungeons, doing quests and fighting ethereal monsters called Shades. Taking after *Automata*, the combat is significantly more dynamic and fluid than it was in the original, with combos and dodges that feel graceful and responsive. Magic, once clunky and slow to use, is now integrated neatly into combat. Parts of the game that were obtuse before are more clearly explained, like a notorious fishing minigame that now is less of a roadblock. *Nier*'s genre shifts pop more, too, now that the core combat mechanics are so much more fun.

I don't know how people are going to respond to *Nier* in 2021, even with all the new bells and whistles. It's far from perfect. But I'm telling you: it's worth it. The original is one of my favourite games ever made, and the remaster improves it. *Nier* is special. This is a new chance to try it out. I think you should take it.

JULIE MUNCY

A tribute to a cult classic and a fabulous remaster that retains what made the original special.
★★★★½



Lola, dearest– I'm here with this young fellow here, and... well, the Warehouse. It's a left up here on Concord Ave, right?

$18.49 | PC, XB1, PS4, Mac, Linux, Switch | hitchhiker-game.com

Hitchhiker

Strap in for a surreal ride across the American midwest.

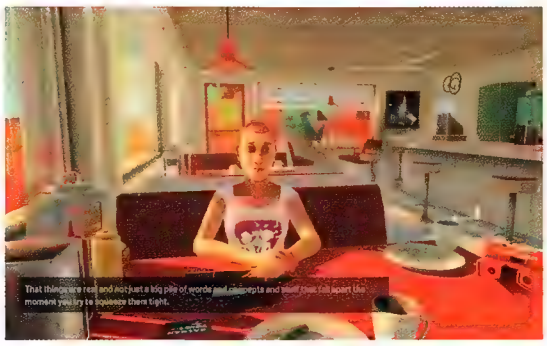
I'm strapped into the passenger seat of a car somewhere in the American midwest. I don't know how I got here, just like I don't know how I'll end up alongside the next four drivers I hitch a ride with in *Hitchhiker*. In an even vaguely real-world context, this scenario could be a little alarming, given how vulnerable I am as an amnesiac hitchhiker with no sense of direction.

But as soon my driver, a raisin farmer called Vern, starts musing about everything from relationships to philosophical raisin-based analogies, a wave of comfort washes over me and I'm all aboard for the ride – wherever it may take me. Why our protagonist is hitchhiking across America will eventually become clear. But while I'm riding shotgun with this procession of philosopher-drivers ruminating about everything from relationships to the strange world that exists beneath shopping mall escalators, the protagonist's own story about his relationship troubles takes a backseat.

It transpires your character has a crumbling long-term relationship, which is tarnished by guilt, jealousy and the painful question of when to let go. You only get glimpses of the relationship itself through flashbacks, photos, and the testimony of the characters you meet, but really the purpose of this entire odyssey across America is to face up to deep-buried truths our wayfaring hero knows about his relationship but is struggling to face up to. Even by the standards of a narrative-driven game, *Hitchhiker* is largely non-interactive beyond looking around, dialogue choices, and the occasional light puzzle. And that's fine, because the writing is strong enough to carry player-passengers like me through its modest length, especially as each ride is broken up by a beautiful vignette illustrating a story that a given driver tells.

It's a shame that such a narrative-focused game doesn't use branching dialogue, player agency in the story, multiple endings, and other well-established tools that make videogames such a powerful storytelling medium.
ROBERT ZAK

A wonderfully written game, but one where you're never in the driving seat.
★★★★☆


That things are real and not just a big pile of words and concepts and ideas that fall apart the moment you try to squeeze them tight.

Free | PC, Linux | bit.ly/FourTravelers

On a Winter's Night, Four Travellers

An accomplished anthology.

This game's three protagonists converge on a train setting to tell their dreadful tales of rejection, delusion, and messing with forbidden lore. The first story, The Silent Room, offers a short, sharp shock in a hotel room, as a man named Carlo awaits his lover, Patrick. Like the other stories, it's set in the 1920s: not an especially good time to be gay, particularly when one man is more comfortable with himself than the other.

The Slow Vanishing of Lady Winterbourne is an affecting tale of gothic horror, where you play as a laudanum-addicted woman in a neglected mansion. The Nameless Ritual is a work of crunchy cosmic horror that nails the Lovecraftian feeling of sticking your toe into an alien, unknowable realm.

As an anthology, as a whole, *Four Travelers* is marred slightly by an insubstantial opening chapter and a linking narrative that ultimately undermines the horror. But in The Slow Vanishing of Lady Winterbourne and The Nameless Ritual, we have two of the most accomplished horror games I've played in ages.
TOM SYKES

There are two fantastic – in both senses of the word – tales on offer in this slightly imperfect horror collection.
★★★★☆

Free | PC | bit.ly/3uBJtpg

Nojong

Mahjong meets match-three.

It took me several plays to fully comprehend *Nojong*, which is a a *Columns*-style match-three game, but where matching blocks is only half of the story. In addition to smushing pairs of two or three identical blocks together, as they fall from the top of the screen, you're also trying to build a beautiful hand of cards. Well, I say cards, but it's actually a hand of nine blocks, initially shuffled from the nine colourful designs: wood, leaves, sun, glass, etc. The blocks in your hand can be swapped for the falling one at any time – for instance, if you need to clear a sun block that's been clogging up the playing field.

The rub, however, is that the falling block will then go into your hand, disrupting your careful pruning with the sudden arrival of, say, some glass or a cube of wood. Arranging a hand can be difficult, as you're also playing a game of *Columns*, which of course gets faster as the rounds go on. But *Nojong* puts a clever new spin on the genre.

TOM SYKES

A concept that plays beautifully once it clicks.

★★★★☆

$21.50 | PC, Mac | clockworkbird.net/games

Silicon Dreams

Are you feeling lucky, cyberpunk?

Here we have a game that not only understands *Blade Runner*, but thoroughly deserves to be mentioned alongside it.

Your character is an android created with the sole purpose of running what is for legal reasons absolutely not a Voight-Kampff machine. The game (mostly) consists of a half dozen or so interrogations conducted with this machine. Usually you'll be speaking with androids, but occasionally with a human. You see, while you will at one point be tasked with determining whether somebody is human or android, the experience for the most part takes sharp turns into territory you'll never see coming.

With no voice acting and relatively simple graphics, there is enormous pressure on the script. The writing is incredible, some of the best I've come across in a game in years. Somewhat ironically, each and every android that I meet seems more human than most of the other countless characters I've met in other games.

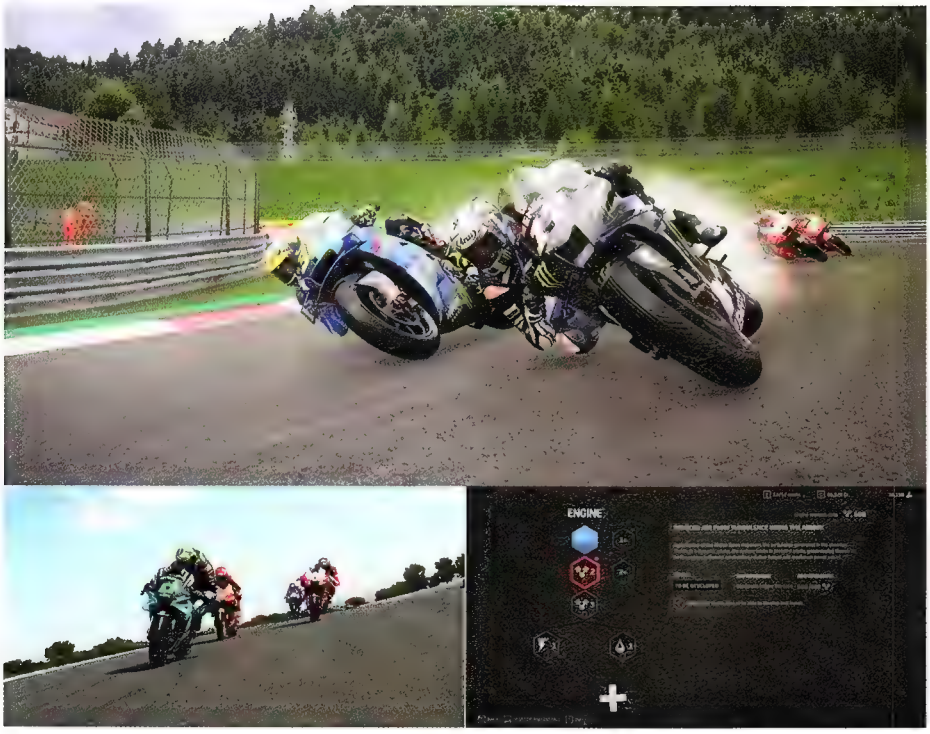
The depth and texture afforded to the interview subjects is not only impressive, it is incredibly important to the experience. I'm being pulled in several directions at once. Every interview has an accompanying report to be filled in and, for androids, one of three choices must be made: release, send for maintenance (which guarantees a memory wipe), or destroy. Yet things are not nearly as simple as they may appear. As an android myself, I am expected to toe the company line at all times. It's made clear that any attempt to defy my employers, or provision of information that contradicts their expectations (intentionally or otherwise), will immediately cast suspicion on me.

While the writing consistently displays impressive subtlety and enormous intelligence, I have mixed feelings about the first ending I got which. Nonetheless, it's an experience that will stay with me for some time, and one that I know I'll be going back to.

LUKE KEMP

An extremely intelligent sci-fi interrogation sim that's unpredictable for all the right reasons.

★★★★½



$69 | PC, PS4, XB1, XBSX/S, Switch | motogpvideogame.com

MotoGP 21

Despite technical wobbles, this one justifies its annual release.

This series has taken a turn sim-wards since its move to UnrealEngine in 2018, but this year's release represents the most noticeable shift in difficulty and realism in years. In particular, changes to suspension and braking make themselves felt in every corner entry and apex, demanding a different approach than last year's game asked of you.

The main course Milestone offers you is a career mode in which your custom rider graduates from Moto3 through Moto2 and finally to the big leagues – or just picks a ride in the fastest category as a rookie, your call.

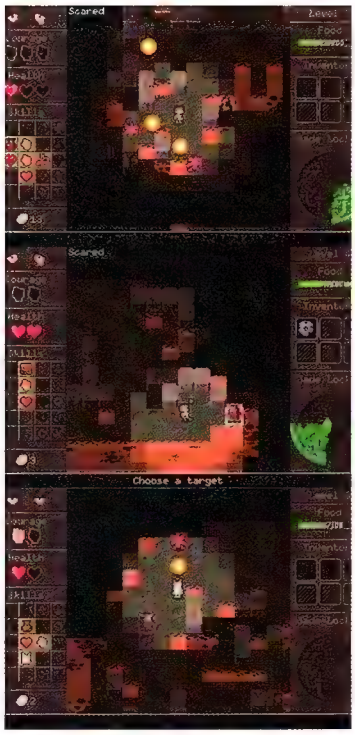
In any event, you're given RPG-like levels of control over your team, earning upgrade points by ticking off objectives in practice sessions and then spending them on bike development. This time you're even assigning specific members of staff to each upgrade project based on their specialisms. All that inter-team tweaking can be rewarding over the long term, particularly if you take *MotoGP 21* up on its offer to run a completely new team from scratch. There's not enough here to prevent annualised release fatigue, though.

That's where the on-track changes come in. However good you were at *MotoGP 20*, you're going to have to completely revise your braking technique here, because the physics changes have a profound effect in those few hundred metres before the apex. It's controller-smashingly easy to apply too much front brake pressure and tip your weight too far forwards, ending up in either a stoppie or a lock-up that sends you sailing past the racing line. The feeling and timing of shifting your rider's weight from one side of the bike to the other is slower, more precarious and more believable now, too. And with those two new facets of the handling are combined, *MotoGP 21* asks you to think one turn ahead, in a very real sense. The frustration is real, then, but the rewards are plentiful.

Even if you hold just a sliver of interest in the exploits of Rossi, and the gang, its meaty career mode can hold you for months, and the uncompromising handling model holds a fascination all of its own.

PHIL IWANIUK

Milestone's latest *MotoGP* is wobbly and unstable in all the right ways, and some of the wrong ones too.
★★★☆☆



Free | PC | benjamin-soul.itch.io

Beasts of Mehetia

Fighting volcanic monsters.

Beasts of Mehetia sets a child battling monsters in a fiery volcano. His main weapon is his courage, and his main form of defence is, er, closing his eyes. This doesn't make the monsters go away, but it does give him a moment to come to his senses, without them in sight to hinder his recovery.

Courage is a resource you use to battle enemies: one point of courage does one damage, and if you run out, you'll expend precious HP instead. While courage does recover naturally over time, this will only happen if there are no enemies present, or if you press the button to close your eyes, causing the viewing area to shrink and giving monsters the chance for a surprise attack. It's a novel mechanic that supports the game's coming-of-age-ritual premise, and that makes this turn-based roguelike feel unique. Roguelikes often take for granted that their heroes are fearless adventurers, but what if their worst enemy was themselves? It's a fun idea.

TOM SYKES ■

Mehetia has a fresh roguelike take, even if its levels get quite samey after a while.
★★★½☆

A dash of conspiracy and the occult spices up the adventure.

DEVELOPER REVOLUTION SOFTWARE **PUBLISHER** VIRGIN INTERACTIVE **RELEASED** 1996 **WEB** revolution.co.uk

Broken Sword: The Shadow of the Templars

Andy Kelly revisits a point-and-click classic.

Broken Sword is a game that knows every great mystery needs a killer premise to hook you in. It begins with an American tourist on vacation in France, sipping coffee outside a Parisian cafe. Then a guy dressed as a clown blows it up. Most people would fly home and try to forget about it, but George Stobbart is not most people: he's an adventure game protagonist. You know what those guys are like. Vacation be damned, he wants to know who tried to kill him – and he's going to find out by picking up a bunch of random objects and solving puzzles with them.

Developed by UK studio Revolution Software and released in 1996, *Broken Sword* is one of the best point-and-click adventure games ever made. It's beautiful to look at. The puzzles are great. The music is sublime. The characters are memorable. The story is full of twists and turns. And it's funny. Like, really funny. It's everything an adventure game should be, and age hasn't dulled its edge one bit.

Four more *Broken Sword* games were released after this one, and while they all have their moments, the original remains the best in the series by quite a margin.

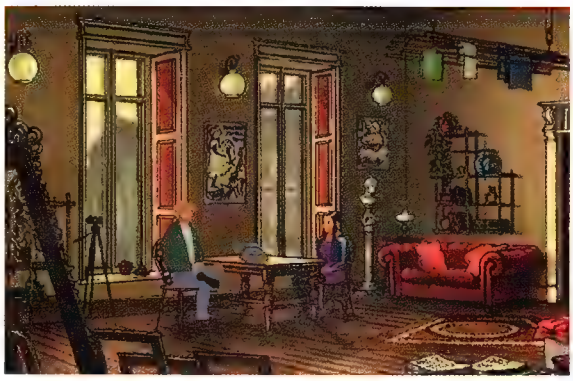
Blade runner

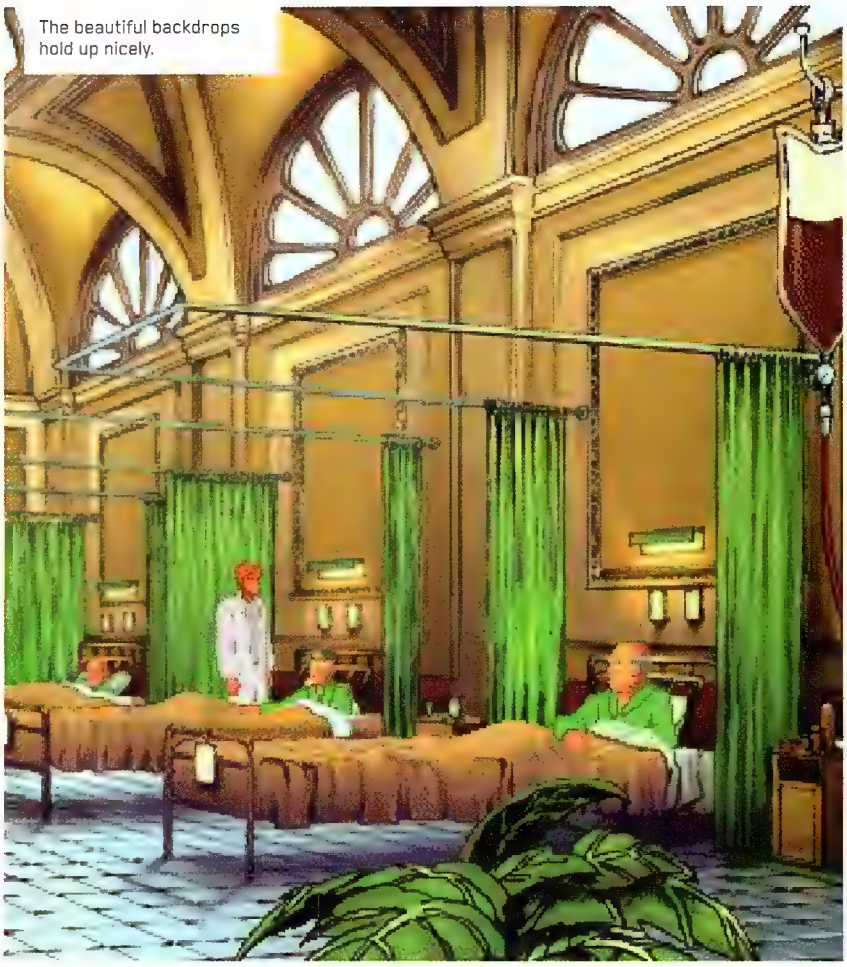
The key thing is that George is not a detective; he's a lawyer with a goofy sense of humour. But nearly being blown up by a terrorist disguised as a clown inspires him to become one, and reveals a deeper side to him. He's smart, resourceful, and absolutely unshakeable when it comes to the pursuit of justice. He searches the streets (and, more than once, the stinking sewers) of Paris for clues. And as you play, his pockets begin to overflow with objects that may or may not be related to the case. It is a point-and-click adventure game after all.

A plastic red nose. A torn piece of weirdly patterned fabric. An ancient manuscript. A small handful of plaster of Paris. A greasy tissue. Man, he loves showing people that gross tissue. Waving it in front of anyone who'll listen, saying "What does this tissue mean to you?", and awaiting the inevitable disgusted response is one of the game's best running jokes.

Every time I meet a new character, it's the first thing I do, just to see their reaction. And the game knows it too, throwing in the odd unexpected response, or one that

Europe's most deadly children's entertainer.





The beautiful backdrops hold up nicely.

takes a subtle dig at you for doing it.

As he investigates the bombing, George finds a partner: a newspaper reporter called Nico Collard, whose apartment George visits regularly throughout the game. They have real chemistry, and I love how their relationship grows over the course of the game. It's one of the best depictions of a friendship forming I've seen in a game. Together the pair find themselves tangled up in an ancient conspiracy that runs far deeper than they ever imagined. The killer clown was just the tip of the iceberg, and one small part of a larger, more complex mystery.

One of the best things about *Broken Sword*'s story is how it's all based on real history – specifically the legend of the Knights Templar. As George hunts for the clown, he learns about this ancient order of knights and a treasure hoard they supposedly hid before they were dissolved and their last Grand Master was burned at the stake in Paris. Author Dan Brown famously leaned on the same mythology in his wildly popular book The Da Vinci Code, which has a lot in common with *Broken Sword* – but Revolution did it first, and did it better.

HISTORY LESSON The Broken Sword series so far

BS: THE SHADOW OF THE TEMPLARS
1996
The game that started it all. Revolution had developed two games before it – *Lure of the Temptress* and *Beneath a Steel Sky* – but this was way ahead of them both in terms of art, design and flair.

BS II: THE SMOKING MIRROR
1997
The second best game in the series. George and Nico's growing relationship makes for some fun moments, the story is great (if not quite as compelling as the original), and the exotic locations provide a great backdrop.

BS: THE SLEEPING DRAGON
2003
The first game in the series to make the leap to three dimensions. Not as artistically sumptuous as its predecessors, and the puzzles get repetitive, but the story is decent and George and Nico are as likeable as ever.

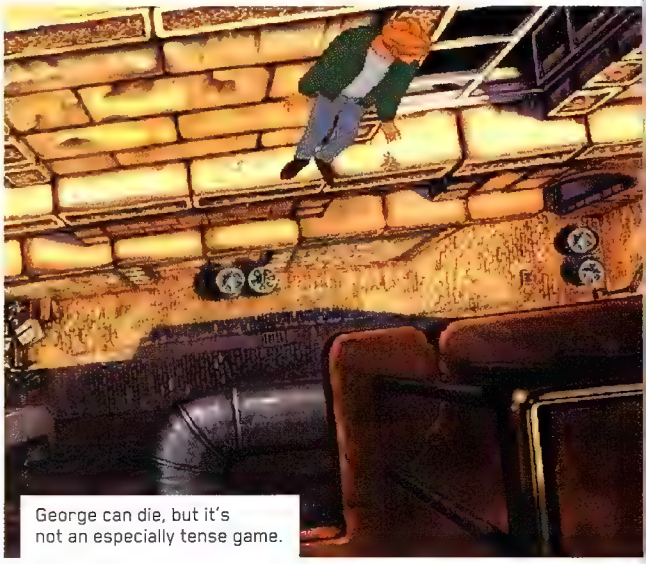
BS: THE ANGEL OF DEATH
2006
Another 3D game, and the first *Broken Sword* to be co-developed with another studio: in this case, Sumo Digital. After the previous game was criticised for having too many action set-pieces, they were reduced in *The Angel of Death*.

BS 5: THE SERPENT'S CURSE
2013-4
For this return to *Broken Sword*'s 2D roots, Revolution raised over $800,000 via Kickstarter and PayPal donations. Not quite as good as the first two games and a little too easy, but captures some of their magic.

In *Broken Sword*, the Templars still exist and are trying to take over the world – a plan George and Nico take it upon themselves to stop. It's a compelling mix of real-world history and the occult, wrapped around an intriguing murder mystery. George's quest for the truth takes him all over the world, from Paris to a sleepy town in Ireland, a Syrian marketplace, a Spanish village, and a train speeding through the Scottish countryside. It's a real globe-trotting adventure, and the colourful, evocative scenery is constantly changing around you.

Ireland is probably the highlight. George is here following a lead about an archeological dig where a priceless Templar artefact has allegedly been dug up. When he

The forbidden love of a man and his floor cleaner.



George can die, but it's not an especially tense game.

gets there, his first stop is MacDevitt's – a rustic country pub specialising in real ale and frequented by talkative locals. If I could drink a pint in any virtual pub, it would be this one. I like to think I'd be able to handle the booze better than George does here, though. Order one too many and he starts getting rowdy. Well, as rowdy as a Californian lawyer can get. And the barman doesn't seem too keen on his drunken idea to turn MacDevitt's into a trendy cocktail bar.

The overarching story in *Broken Sword* is great, but it's moments like this that make it really special. The quiet moments where the well-written characters are given a chance to shine, and the warm, witty humour comes to the forefront. It's an incredibly cosy game. The slow pace, hand-painted backgrounds, and orchestral music give it a really pleasant atmosphere. If you've ever watched a British detective drama, it has a similar vibe. Thrilling, exciting, but in a pretty subtle way, with lots of nice scene-setting and quirky, light-hearted conversations in between all the murders.

George meets a lot of memorable characters, including a hospital cleaner whose best friend is a floor polishing machine called Mr Shiny, a detective convinced he has psychic powers, and a mischievous youngster called Liam Maguire who tries to rope him into a scheme to steal him a crate of lager. And who can forget Lady Pierremont, an obscenely posh hotel guest with a plummy English accent who helps George pilfer the key to a room through sheer upper class arrogance. I love all these weirdos, and their voices are forever etched into my mind.

Unusual suspects

The voice acting, incidentally, is brilliant. It's quite scrappy in places, occasionally sounding like it was recorded in a bathroom stall (it might have been; Revolution was a small studio at the time). But that only adds to its charm. And actor Rolf Saxon (who has appeared in a bunch of stuff, including *Tomorrow Never Dies*, *Saving Private Ryan*, and *Mission: Impossible*) is perfect as George Stobbart. In fact, I don't know if the character would work half as

THEATRE OF DREAMS
A brief history of *Broken Sword*'s engine

Broken Sword, like most games developed by Revolution Software, uses an in-house engine called Virtual Theatre. The studio was formed in 1990 by Charles Cecil, Tony Warriner, David Sykes, and Noirin Carmody, and its first project was *Lure of the Temptress*. This fantasy adventure game (which is now free on GOG) was the debut of the Virtual Theatre system, which would see characters moving around the world, travelling between locations, and following simple routines – around which many of the puzzles were designed. *Broken Sword*, however, doesn't actually utilise Virtual Theatre to the same degree, but an iteration of the engine has been in almost every Revolution game to date, including its latest, *Beyond a Steel Sky*.

Probably nothing suspicious happening here.

well without him. He brings just the right amount of warmth and deadpan humour to the role, but with a tough, determined edge – which mirrors the two sides of the character. *Broken Sword*'s animation is also unbelievably lavish and expressive, which is another important part of why its characters are so memorable. The way they move says as much about them as their voices, whether it's Lady Pierremont's indignant march towards the reception desk at the hotel, or Sean Fitzgerald twitching and eyeing the door nervously in MacDevitt's, visibly worried about something. Artistically, it's one of the prettiest and most atmospheric adventure games of the period. And even though it looks quite low-res and pixelated on big, modern monitors, the quality of the art direction shines through.

But as laid back as *Broken Sword* is, you can still die. Mistakes that lead to George's untimely demise are usually clearly signposted, but you won't be able to resist putting him into dangerous situations to see what happens. You can always reload. Honestly, these scenes feel kind at odds with the rest of the game. It's quite jarring to go from this fun, silly, rip-roaring adventure, to lovely, goofy George being given a pair of concrete shoes by some shady gangsters and thrown into the Seine. It does at least add a sprinkle of genuine danger to the game.

Baaaa humbug

Of course, you can't talk about *Broken Sword* without mentioning the goat puzzle. It stumped so many people that it even has its own Wikipedia page. It's actually pretty simple. When the goat knocks you down, quickly click the old plough on the other side of the screen to trap it. The problem is, there are no other timing-based puzzles in the game. None up until that point, and none after. So you can understand why it has most players reaching for a walkthrough. However, if you're playing the *Director's Cut* version of *Broken Sword*, the timing element has been removed entirely, making the goat puzzle not so infamous.

But which version should you play? The *Director's Cut* is excellent, adding a whole new prologue chapter where you play as Nico, new puzzles, neat character portraits by Dave 'Watchmen' Gibbons, a nicely designed hint system, and more. But some elements I'm not so keen on, like the comic book-style text bubbles. I personally prefer playing the original version on ScummVM, because it's the one I remember playing when I first discovered the game. But either way, you're going to have a good time.

It's a shame that dumb goat puzzle is what most people think of when they hear the name *Broken Sword*, because it's really the least interesting thing about it. This is a smart, funny and deeply charming adventure game, and still wonderfully playable today. The puzzle design is mostly logical and even-handed, rarely slipping into the brain-twisting absurdism of many other point-and-click adventures from the mid-to-late '90s.

Wacky puzzles, while a staple of the genre, don't age well, which I think is part of *Broken Sword*'s enduring appeal. It's a game I play at least once a year, and every time I do, the magic is still there. ■

CHIP CHAT

JOEL BURGESS REPORTS ON THE UNUSUAL SIDE OF TECH NEWS

Real and fake Elon Musks are here to hurt your crypto portfolio

SEC says investors lost US$2 million to fraudsters, but the real Elon cost crypto much more.

The federal Trade Commission reported in May that consumers had been scammed out of around US$2 million in cryptocurrency by fraudsters impersonating Elon Musk. A number that perhaps pales in comparison to the amount the crypto market would have lost to the real Musk in the Tesla CEO's apparent Bitcoin pump-and-dump scheme. In February, Tesla announced it had purchased US$1.5 billion of Bitcoin, causing the price of the crypto currency to surge 20 percent in a day and allowing the company to sell 10 percent of its holdings for a US$101 million boost in Q1 profits. In May, Tesla then announced it would no longer accept Bitcoin payments on account of environmental concerns, which haven't changed since February, but acted to tank the market after some speculated that Tesla had sold the rest of its holdings.

New app lets you pay to control people's lives

Someone dragged a fictitious dare app from a movie into the real-world social media scene.

How much would you pay to choose what a stranger has for dinner? If you had to think about your answer, then we suspect a new app called Newnew, now available on the App Store, is going to be your next social media addiction. Despite its name, the app is basically a boring re-imagination of the fictitious app at the centre of the 2016 Millennial film *Nerve*, which made players complete increasingly dangerous dares suggested by 'watchers' for money. Newnew is essentially the same thing with users able to pay $5 to choose what outfit someone wears or put forward $20 to suggest a host do whatever you want.

Beavers take down the web for a remote Canadian town

ONLY IN CANADA.

900 internet users in a remote part of Northern Canada suffered an internet outage in April, as a result of local beavers gnawing through a primary fibre-optic cable. Despite being concealed in conduit 11.4cm thick and buried about a meter underground, the beavers managed to chew through the cables 'in multiple places' according to reports. The beavers were assumed to be looking for materials since some of the internet provider's fibre marking tape had been used by the critters in a dam they'd constructed nearby. The outage lasted 36 hours and impacted cable TV, phone connections and of course internet availability in the Tumbler Ridge municipality of British Columbia.

Apple admits 'unacceptable' levels of malware on today's Macs.

MACS GET VIRUSES NOW TOO, ACCORDING TO APPLE.

Apple was once considered virtually virus free, but these days according to Apple execs the OS has an unacceptable level of malware. The admission came from Apple's Head of Software Engineering, Craig Federighi, in a court case between Apple and Epic over the anti-competitive nature of the App Store. Apple's not often one to highlight its platform's shortcomings, but the admission forms the basis of the company's defense: that the walled garden Apple maintains through its AppStore is essential for security, and isn't just a tool to monopolise the iOS software market. ■

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